THE HAWAIIAN PLANTERS' RECORD

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A quarterly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

Fertilization at Waipio

For several years now the general practice at the Waipio substation has been to use nitrogen only as a fertilizer. This is obtained mainly from nitrate of soda, although ammonium sulphate and ammonium nitrate are also used. We aim to use whichever material is cheaper per unit of nitrogen. We carry on several tests at Waipio where phosphoric acid and potash are applied in addition to the nitrogen. In the last crop one of our tests gave a small response to phosphoric acid. Acting on this indication we are applying phosphoric acid to our young cane.

We use from 280 to 350 pounds of nitrogen per acre, depending upon how old the cane will be when harvested and upon the needs of the field, etc. Short ratoons or short plant get about 280 to 300 pounds per acre; the long crops from 310 to 350. To supply this amount of nitrogen requires from 1800 to 2250 pounds of nitrate of soda or 1350 to 1700 pounds of ammonium sulphate per acre.

We apply the first dose of fertilizer, 50 pounds of nitrogen, from, say, 323 pounds of nitrate of soda per acre to plant cane approximately a month after planting or when the young cane has from two to three leaves. We apply the same amount of fertilizer to ratoons with the first water, say, two or three weeks after the field is harvested, as the young shoots begin to show above ground.

The second dose of fertilizer, twice as much as the first dose, is applied about six weeks after the first one. We have no fixed time for this application, which depends upon the cane. That is, we watch the cane very closely and, as soon as it shows the slightest sign of slower growth or changing color, the fertilizer is applied. The idea is to always keep enough available plant food in the ground to keep the cane growing without check.

The third dose of fertilizer is applied in the same way; the cane is closely watched and as soon as it shows signs of slowing up, the fertilizer is put on. This is usually about 3 months after the second dose. The third application is from 130 to 160 pounds of nitrogen (840 to 1,000 pounds of nitrate of soda).

The cane is now 5 or 6 months old, and for the shorter crops (up to 18 months) has received all its fertilizer. This allows the cane plenty of time to use up the fertilizer and mature before harvest.

In the longer crops, over 18 months, we add an extra dose of 50 pounds of nitrogen, if the cane shows the need of it.

To express briefly what we are attempting to do at Waipio, will say that we watch the cane very closely and, as soon as (or before) the cane gets "hungry" we give it a big feed.

In order to get a quicker indication of a coming check, we have started a system of growth measurements at Waipio. We are measuring a number of cane stalks in each field each week and plot the growth in curves. We believe this will give better and quicker indications of the crop needs than when depending on the eye. Ewa Plantation has been making these measurements for a number of years and has gotten valuable information.

To use this rather large amount of nitrogen, the cane should get regular irrigation. We try to make our rounds in not over 20 days. In the hot summer we try to make it every two weeks. We cannot always do that, but we feel that any longer intervals of irrigation represent a loss.

When we say 50 pounds of nitrogen we mean 325 pounds of nitrate of soda. To make this point clear, the following typical examples of fertilization at Waipio are given for crops of different lengths:

"A" (a 15 months crop)

		Interval between operations
April	25, 1921—Previous crop harvested.	
May	15, 1921—Applied 325 lbs. of nitrate of soda..................	20 days
July	1, 1921— " 650 " " " " "	46 "
October	1, 1921— " 800 " " " " "	92 "
August	1, 1922—Harvest	304 "

"B" (a 20 months crop)

August	15, 1921—Previous crop harvested.	
Sept.	1, 1921—Applied 325 lbs. of nitrate of soda..................	15 days
October	15, 1921— " 800 " " " " "	44 "
February	1, 1922— " 800 " " " " "	108 "
May	1, 1922— " 325 " " " " "	88 "
May	1, 1923—Harvest	365 "

To use such heavy fertilization to advantage, all operations must conform. There must be unusual care in connection with all details.

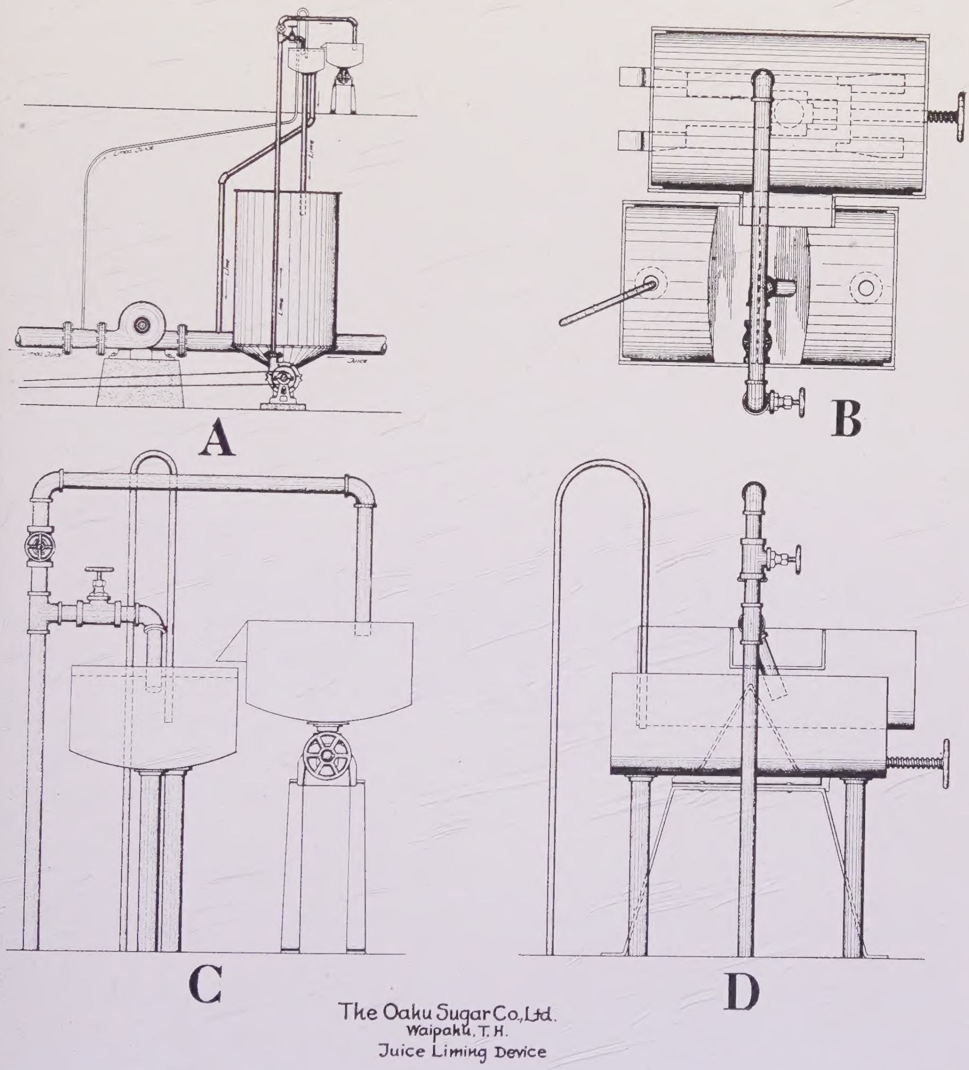
In the absence of information that any areas do not require phosphoric acid and potash, it is better, of course, to apply fertilizer containing these materials.

J. A. V.

A Continuous Juice Liming Device.

By W. R. McAllep.

Through the courtesy of the Oahu Sugar Company we are able to present drawings of an arrangement for continuously liming the mixed juice, designed and installed just prior to the present grinding season.



A in the accompanying cut is a sketch of the whole installation showing the mixed juice pump, the pipe for introducing lime milk into the juice on its way from the supply tank under the scales to the pump, the sampling line running back from the pump discharge, the tank for milk of lime, the pump for circulating the lime milk, and the device for regulating the quantity of milk of

lime, continuously added to the juice. *B, C* and *D* are respectively top, end and side views of the latter device.

The regulating device is installed close to the mixed juice scale so that it can be conveniently controlled by the scale man. It consists of two boxes, one stationary and the other movable. The stationary box is divided by a partition shown in *D* and *E*. A pipe leading back to the lime reservoir from one side of this partition returns the surplus milk of lime. The sampling pipe discharges into the other end of the stationary box. A pipe carries the lime and the juice discharged from the sampling pipe from this end of the box into the mixed juice pump suction. The movable box is mounted on an arrangement similar in principle to the cross feed of a lathe. The lime milk enters this movable box and overflows in a broad stream, the outlet shown in the drawing. The partition in the stationary box divides the stream of milk lime, a part being used in the juice and the surplus returned to the lime supply tank. The amount of lime used in the juice is regulated by changing the position of the movable box. A further very close adjustment is made by slightly opening or closing the lower of the two valves shown in *C*, thus changing the amount of lime flowing over the outlet of the movable box. A considerable excess of lime milk above that required for the juice is circulated. This keeps it thoroughly mixed and renders a stirring device in the supply tank unnecessary.

The lime is instantly mixed with the juice in the pump and immediately after altering the adjustment, the juice running from the sampling pipe, which is allowed to run a full stream, shows the exact effect of the change. Waiting for a quantity of lime to mix with a tank of juice, and uncertainty as to whether or not the mixture is complete, and the sample finally secured representative, is entirely avoided.

The operation of this device has been most satisfactory and decided benefits have accrued through its use. As the device is conveniently located, adjustments are easily made and there is no delay between making the adjustment and determining its full effect, the scale man can keep the juice accurately limed to the desired point without difficulty. Though the juice at this factory varies greatly in lime requirement, since this installation has been used, the juice has been kept very evenly limed. The precaution is taken to notify the scale man of a change in cane at the mill.

This installation was moderate in cost, having been made entirely of material on hand. A similar installation could be made in most factories at nominal expense other than for the labor involved and possibly for a pump to circulate the milk of lime. Judging from the much closer control of the clarification secured after using this installation at Oahu Sugar Company, similar installations at other factories would be most desirable.

This system of liming raw juice is novel and letters patent have been applied for in the name of Charles J. Fleener, head sugar boiler for Oahu Sugar Co. Mr. Ernest W. Greene and Mr. W. Richardson, working with Mr. Fleener, contributed largely to making it a success.

The Honolulu Iron Works Company, appreciating the simplicity and efficiency of this improved method of applying lime to sugar juices, have arranged to act as agents for the owners of the rights, and any one desiring further information can obtain it by enquiring of the Honolulu Iron Works Co.

Migration of Aphids.

Observations on the migration of Aphids have recently been made in Europe, which are of interest to us in Hawaii. C. Borner has shown that species of these delicate insects are carried from the German or Dutch coast to the islands of Memmert and Heligoland, distances of fifteen and thirty-nine miles respectively. These insects must be carried out to sea in myriads, as large numbers reached the islands.

These observations are of interest to us as they demonstrate how easy it is for our corn aphid, which carries the Yellow Stripe disease, to scatter over our cane fields, and how the elimination of grasses and corn in and around our cane fields may greatly reduce the Yellow Stripe but will not entirely eliminate it.

F. M.

The National Research Council.*

By Vernon Kellogg.†

The National Research Council is a cooperative organization of scientific men of America, including also a representation of men of affairs interested in engineering and industry and in the fundamental or "pure" science on which the applied science used in these activities depends.

The Council was established by the National Academy of Sciences at the request of the President of the United States, under the Congressional charter of the Academy, to coordinate the research facilities of the country for work on war problems involving scientific knowledge and in 1918, by Executive Order, it was reorganized as a permanent body. Its essential purpose is to promote scientific research and the application and dissemination of scientific knowledge for the benefit of the national strength and well-being.

In the character of its organization and support it differs materially from other similar, and in some cases identically-named organizations which have been established in recent years in several other countries, notably England, Canada, Australia, Japan, Italy and Czecho-Slovakia. These organizations are all Government-supported and to some extent Government-controlled. The American National Research Council, although partly supported during the war period by the government and primarily devoted at that time to activities of direct assist-

* This and subsequent articles on this subject are reprinted from circulars distributed by Council.

† Permanent Secretary of the National Research Council, and Chairman of its Division of Educational Relations.

ance to the government, is now entirely supported from other than governmental sources, and is entirely controlled by its own representatively selected membership and democratically chosen officers. The Council maintains, however, a close cooperation with government scientific bureaus and their activities. It enjoys the formal recognition and active cooperation of about seventy-five major scientific and technical societies of the country, its membership being composed in large part of appointed representatives of these societies.

The Council is composed of a series of major divisions, arranged in two groups. One group comprises seven divisions of science and technology representing, respectively, physics, mathematics, and astronomy; chemistry and chemical technology; biology and agriculture; the medical sciences; psychology and anthropology; geology and geography; and engineering. The other group comprises six divisions of general relations, representing foreign relations, government relations, state relations, educational relations, research extension, and research information. As subordinate or affiliated lesser groups each of these divisions comprises a larger or smaller series of committees, each with its special field or subject of attention. There are certain other committees, administrative and technical, which affiliate directly with the executive board of the Council. The general administrative officers of the Council are a chairman of the executive board, three vice-chairmen, a permanent secretary, a treasurer, and a chairman of each of the various divisions. All of these, except the permanent secretary and the treasurer, are elected annually by the executive board or by the members of the division.

The financial support of the Council is derived, first, from a gift of five million dollars from the Carnegie Corporation of New York, of which a part is to be used for the erection of a suitable building in Washington, now in course of construction, for the housing of the Council and the National Academy of Sciences, and the remainder is to serve as a permanent endowment for the Council; and, second, from other gifts from various sources, mostly made for the specific support of particular Council undertakings. In this latter way the Council has so far received more than two million dollars, one million of which, given by the Rockefeller Foundation ($750,000) and the General Education Board ($250,000), is devoted to the maintenance, through five years, of one series of research fellowships in physics and chemistry and another in medicine. Both the Rockefeller Foundation and the General Education Board have made other gifts to the Council for the support of special scientific projects, while still other gifts have come from numerous donors, including philanthropic foundations, industrial concerns and individuals. The funds, about $200,000, for the purchase of the land on which the Council and Academy building is being erected, were obtained from more than a score of individuals interested in the promotion of the development of science.

The Council maintains two regular series of publications, one called Bulletins, of which nineteen numbers have so far been issued; the other called Reprints and Circulars, of which thirty-six numbers have appeared. In addition it has so far issued 170 miscellaneous publications. The Council also assists both financially and editorially in the publication of the Proceedings of the National Academy of Sciences.

The Council is neither a large operating scientific laboratory nor a repository of large funds to be given away to scattered scientific workers or institutions. It is rather an organization which, while clearly recognizing the unique value of individual work, hopes especially to bring together scattered work and workers and to assist in coordinating in some measure scientific attack in America on large problems in any and all lines of scientific activity, especially perhaps, on those problems which depend for successful solution upon the cooperation of several or many workers and laboratories, either within the realms of a single science or representing different realms in which various parts of a particular problem may lie. It hopes to bring to bear upon scientific problems the wisdom of numbers—where such wisdom is not made unnecessary by the competence of genius. It particularly purposes never to duplicate or in the slightest degree to interfere with work already under way; to such work it only hopes to offer encouragement where needed and support when possible to be given. It hopes to help maintain the morale of devoted but isolated investigators and to stimulate renewed effort among groups willing but halted by obstacles. It will try constantly to encourage the interest of universities and colleges in research and in the training of research workers, so that the inspiration and fitting of American youth for scientific work may never fall so low as to threaten to interrupt the constantly needed output of well-trained and devoted scientific talent in the land. For with any serious interruption in the output of American science and scientific workers, the strength of the nation will be immediately threatened.

The methods of contributing practical assistance to American science which the Council has so far adopted are various, all of them, however, in harmony with the general point of view and policy outlined above. One method is the establishment of special committees of carefully chosen experts for specific scientific subjects or problems urgently needing consideration. These special committees plan modes of attack and undertake, with the assistance of the general administrative officers of the Council, to find men and means for carrying out the plan. Another method is that of bringing together industrial concerns interested in the development of the scientific basis of their processes and inducing them to support the establishment of special investigations under the advice of experts representing the Council. Still another is the stimulation of larger industrial organizations, which may be in the situation to maintain their own independent laboratories, to see the advantage of contributing to the support of pure science in the universities and research institutes for the sake of increasing the scientific knowledge and scientific personnel upon which future progress in applied science absolutely depends. Other methods are the direct maintenance of university research fellowships; the publication of valuable scientific papers for which there is at present no other suitable prompt means of issuance; the preparation of bibliographies and abstracts of current scientific literature; the setting up of well-considered mechanisms for the collection and distribution of information about current research, university and industrial research laboratories and facilities, research personnel, and so forth; and the dissemination, through the press and magazines of popular but authentic scientific news and information for the sake of increasing the public interest in and support of productive scientific work. Still other forms of activi-

ties might be listed, but these mentioned no doubt adequately enough illustrate the Council's methods.

What America needs is not to give up its individual initiative in science, but to add to that initiative means for coordination and organizaton. We need a wider recognition and an increased social evaluation of the place of scientific research in our national life. From these will come a willingness not only to encourage and to support individual scientific effort, but also to insure a greatly augmented productivity of all present research agencies and a much more effective coordination of them with regard both to the planning and the executing of those broad, inclusive scientific investigations which are required for the solution of the problems upon which depend the most effective use of our national resources, the highest production in our agriculture and industry and the maintenance and increase of our national health. In a word, we need more, and better, and better-coordinated science for the preservation and development of our national strength and well-being. The National Research Council is an organization that hopes to contribute in some degree to the meeting of this need.

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Paul Brockett, Assistant Secretary; Assistant Secretary, National Academy of Sciences, Washington, D. C.

Alfred D. Flinn, Assistant Secretary (by reciprocal arrangement with Engineering Foundation); Director of Engineering Foundation, 29 West Thirty-ninth Street, New York, N. Y.

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Division of Biology and Agriculture—F. R. Lillie, Professor of Embryology, University of Chicago, Chicago, Ill.

Division of Anthropology and Psychology—Raymond Dodge, Professor of Psychology, Wesleyan University, Middletown, Conn.

The Research Information Service of the National Research Council.

What is the Research Information Service?

The Research Information Service is a clearing house for scientific information; a central switchboard which connects you with the persons or materials in which you are interested; a liason service between you and the informational store-houses of this and other countries.

Our country is full of good sources of information. In the east and west, north and south, there are libraries, informational bureaus, associations, industrial concerns and individuals who have compiled valuable data for research workers. The United States Government itself has a great amount of useful information in its scientific departments in Washington.

The difficulty in obtaining scientific information is not *lack of sources,* but *lack of information about sources.*

The Research Information Service Specializes In Sources

The aim of the Service is to furnish useful information about scientific methods and results, and their practical applications in engineering, industry and education. In the furtherance of this aim it has carefully designed and constructed informational apparatus whose value will steadily increase with use. The development of these informational mechanisms and their operation are in charge of a technical staff. This assures intelligent interpretation of requests and skillful search for the information desired.

Informational Mechanisms

To meet specific needs for research data the Service has developed essential apparatus and clearing-house devices. Some important parts of this machinery are listed below:

Research facilities: Funds; Apparatus; Laboratories.
Bibliography of bibliographies: Published; Unpublished.
Biographical Records: Scientists; Technologists.
Topical references: Problems; Projects; Methods; Processes; Results.
Photostatic reproductions: Rare reports; Unpublished data.

What Does Information Cost?

No charge is made for replies to inquiries which do not necessitate a special search for information.

Requests for data which can be secured only by expending considerable time are acknowledged with an estimate of the necessary cost of assembling what is desired. The Service then awaits instructions.

Kinds of Information

Who?—Who knows . . . who has undertaken . . . who can find out . . . who is qualified . . . who is available . . . who has the facilities?

Personnel files: Bibliographic records of American investigators are carefully catalogued. Their specialties are minutely indexed for purposes of classification. A mechanical system is used for selecting names of investigators who have specified research qualifications. Answering requests about current activities is thus simplified.

The Service has innumerable contacts with investigators, their laboratories, interests and present work.

How?

How may an investigator proceed with a research problem; how may he obtain apparatus, or other equipment; how may he apply for supporting funds; how may he find out about methods, processes and technique?

Catalogue and index of apparatus and supplies: A large collection of scientific instrument and supply catalogues and lists has been assembled and indexed for ready reference. This constitutes an excellent source of information about types, availability and prices of equipment for research.

File of research funds: Medals, prizes, grants, fellowships and scholarships for the encouragement or support of research are listed in the Information Service. Is there a better place to seek knowledge of funds for research?

What?

What research is in progress; what is projected; what reports are published; what specific lists or bibliographies are available?

Central reference file: References to information about all kinds of scientific problems, methods, and results are systematically made. A classification skeleton has been adopted which can be expanded to provide, if necessary, for several millions of reference topics.

Surveys of bibliographies: Bibliographies on numerous scientific and technical subjects have been listed. For several of the natural sciences lists of published and of unpublished bibliographies are being compiled by competent persons either for use in the files of the Research Information Service, for publication, or both.

Indexes and abstract journals: Abstracts and indexes of publications are at hand for use as sources of information about reports of research.

Resources of Libraries: Library facilities and equipment in every part of the country are known. They often are cited to isolated investigators.

Publication of compilations: When compilations of information are such as to be widely useful they are published either in the Bulletin or the Reprint and Circular Series of the National Research Council.

Where?

Where is a certain kind of laboratory; where may specific problems be submitted for solution; where may supporting funds be obtained; where can an obscure journal or periodical be found; where are the people who are interested in given problems?

File of industrial laboratories: As a directory to sources of research work this compilation has proved particularly useful. It gives pertinent information about laboratories and special facilities for research.

List of serials and periodicals: Information about thousands of serials located in Washington libraries has been assembled. With such a working list the staff can quickly turn to the proper library sources for desired literature.

At Your Service

The technical staff can call upon members of the Research Council for advice or assistance. Representative as it is of sixty-six of the major scientific and engineering societies of the country, the Council, through its various divisions and committees, has wide and important contacts. It is in touch with research activities in educational, industrial and governmental institutions and with current work and projects in mathematics, physics, astronomy, chemistry, geology, geography, zoology, botany, physiology, psychology, anthropology, agriculture, medicine and engineering.

This cooperative aid is at the service of those interested in the advancement of science and technology.

TYPICAL REQUESTS

(Requests should be clear and specific.)

1. Where may oelic, linolic, and certain other acids be procured?
2. Information as to occurrence of boron in plants and animals.
3. Names of ferns that can furnish calcium silicate.
4. The solubility and toxicity of para-dichloro-benzene.
5. Reference to studies of acquired resistance to tuberculosis, diphtheria, and inheritance of resistance.
6. Status of knowledge on biological effects of use and disuse.
7. Where may colored slides representing types of edible and non-edible mushrooms be obtained?
8. Mortality rates of French Canadians in this country and in Canada.
9. What is known about the chemical composition of the gastric crypts of the stomach mucosa?
10. How may growth of yeast be stimulated?
11. Studies on the gastro-intestinal tract of the turtle.
12. Brashear formula for silvering glass.
13. Information on the manufacture and testing of writing ink.
14. Where may powdered shellac be purchased?
15. Reference to investigations on methods of making peat fuel.
16. Information about smoke prevention.
17. Verification of the following reference: Ranke, J. Tetanus—Eine physiologische Studie. Leipsic. 1865.
18. Desired: a photostat copy of a certain scientific article.
19. Bibliography: Waterproofing of cement and concrete.
20. Bibliography on "Absorption spectra of inorganic compounds."
21. Where may Braun tube for A. C. work be obtained?
22. Desired: plans of buildings constructed by universities for departments of science.
23. Where may Nernst Lamp glowers be obtained?
24. Desired: name of firm for quartz blowing.
25. Information about instrument devised to measure ductility of pasty materials such as grease or dough.
26. Names of specialists studying the control of cotton boll weevil and other insect enemies of cotton plant.
27. A list of the deans of engineering schools.
28. List of psychologists concerned with psychology of music.
29. List of suitable candidates for assistant professorship of biology.
30. List of the outstanding women in science from 1850 on.
31. Recent books on the characteristics and distribution of the races of Europe.
32. Where may Army Mental Tests be obtained?
33. The Negro in science, invention, education, art and literature.
34. A list of the industrial organizations interested in the use of psychological tests.
35. Bibliography on latent effects of mustard gas poisoning.
36. Assistance in securing Stenquist test of mechanical ability.

Special Announcement to American Chemists and Engineers.

You Are Invited to Use Research Information Service of the National Research Council.

RESOURCES

STAFF OF SPECIALISTS

Chemistry and chemical engineering are well represented on the technical staff of the Research Information Service. The following at present are resident members of the staff of the National Research Council and available for assistance to the Information Service:

E. W. Washburn, Chairman, Division of Chemistry and Chemical Technology.
Clarence J. West, Secretary, Division of Chemistry and Chemical Technology.
H. F. Whittaker, Scientific Associate, Research Information Service.

PERSONNEL FILES

Essential information about research chemists and chemical engineers in the United States is found in the personnel catalogue of the Information Service. This file has been translated into mechanical form so that information about persons may be obtained quickly by a process of mechanical sorting. By this method desired information may be readily obtained about persons eligible for certain tasks or appointments, or about research facilities, scientific resources, prevailing interests, and current work.

BIBLIOGRAPHIES IN CHEMISTRY AND ENGINEERING

The Service is developing a catalogue of published and unpublished bibliographies in chemistry and chemical engineering. You are welcome to any bibliographical information we have. If we do not have what you need, we shall gladly try to locate it for you. For the promotion of research interests, we earnestly solicit from all investigators reports which will make our bibliographic records more complete.

SCIENTIFIC APPARATUS AND RESEARCH CHEMICALS

A file now containing more than 500 catalogues of manufacturers and dealers in scientific instruments is maintained. Information about sources, availability and loan of apparatus and equipment is thus accessible. A compilation showing the manufacturers of research chemicals has also been made for use especially in referring to the rarer products.

RESEARCH SUBSIDIES

The Service maintains current information about available fellowships, scholarships, grants, prizes, and funds used for encouraging scientific research in the United States.

CURRENT WORK

The Service has numerous and important contacts with investigators, laboratories and other research interests. Non-confidential data about research in progress will be supplied on request. If you wish to have contacts with investigators working on problems similar or related to yours, we shall be glad to give you every aid possible.

COST

No charge is made for replies to inquiries which do not necessitate special search for information or special expenditure for preparation of our report. In other cases requests are acknowledged with an estimate of the necessary cost of assembling what is desired. The Service then awaits instructions. Nominal charges are made for time involved in special searches and for photostats of rare reports.

SAMPLE REQUESTS

1. Personnel. 3255 (November 17, 1922): A list of women who have received a Ph.D. degree in organic chemistry.
2. Bibliography. 1196 (October 10, 1921): Literature references dealing with high temperature experiments with carbon leading to its crystallization for the production of artificial diamonds.
3. Design. 2839 (July 31, 1922): Design of automatic thermostatic regulator for automobile radiator and recommendation of liquid to be used in it.
4. Apparatus. 155 (December 11, 1920): Where may a special type of spectrometer be obtained? (Above apparatus was described in a technical paper.) 3050 (October 11, 1922): What companies manufacture or sell hydrometers for determination of the specific gravity of liquids ranging between 2.00 and 3.33?
5. Process. 3138 (October 28, 1922): Request for information on the commercial dehydration of fruits and vegetables.

REPETITION OF REQUESTS

Correspondents occasionally apologize for the frequent use they make of the Service. This attitude is the result of incomplete understanding of the purpose of our organization. The Research Information Service is maintained to promote science and its applications. The extent to which the investment is justified is measured by the use that is made of it. The more it is used, the more valuable it can become.

Special Announcement to American Biologists

Concerning the Research Information Service of the National Research Council.

RESOURCES

STAFF OF SPECIALISTS

Biology is well represented on the technical staff of the Research Information Service. A Scientific Associate, serving jointly as Executive Secretary of the Division of Biology and Agriculture, and a Technical Assistant are immediately available. The Service also has for consultation the membership of the Division of Biology and Agriculture and the chairmen of other divisions of the Council having related intersts.

BIBLIOGRAPHIES

In catalogues of manuscript bibliographies the Service has important references to unpublished compilations on biological subjects which supplement importantly existing abstracts and indexes. These unpublished sources are useful where recent information is desired. Bibliographic records are in charge of an experienced librarian and classification specialist who coordinates the various resources of the Council for effective response to each inquiry.

LIBRARY DISTRIBUTION OF PERIODICALS

Compilations have been made of union and special library lists for use in advising investigators where particular periodicals may be obtained. Information can be furnished about the availability of serial publications in the principal domestic libraries.

PERSONNEL FILES

Valuable information about investigators in the biological sciences is available in the personnel catalogue of the Research Information Service. This alphabetical catalogue is supplemented by a mechanical file which will shortly be in operation for investigators in plant and animal biology and agriculture. With this organization of personnel information the Service can refer to persons qualified for stated needs as indicated by research facilities, scientific resources, prevailing interests, current work, etc. The personnel mechanism related to the records of psychologists has been described in Bulletin No. 22 of the National Research Council.

RESEARCH SUBSIDIES

The Service maintains current information about available fellowships, scholarships, grants, prizes, and funds used for encouraging scientific research in the United States. The maintenance of this information is greatly facilitated by wide and varied contacts with investigators and research agencies.

SCIENTIFIC APPARATUS AND RESEARCH CHEMICALS

A file now containing more than 500 catalogues of manufacturers and dealers in scientific instruments is maintained. Information about sources, availability, and loan of apparatus and equipment is thus available. A compilation showing the accessibility of research chemicals has also been made for use especially in referring to manufacturers of the rarer products.

SAMPLE REQUESTS

1. Bibliography: Existing bibliographies on the subject of plant growth in relation to climate with particular reference to corn and sunflowers in relation to sunshine, precipitation, evaporation, temperature, etc.

2. Personnel: (1) A list of young zoologists interested in embryology and invertebrate morphology. (2) The percentage of women engaged in botanical research.

3. Funds: A grant of two hundred dollars to purchase apochromatic optical equipment for the study of chromosome dimensions.

4. Equipment: A motion picture film on "Mitosis."

COPIES OF ORIGINAL SOURCES

With photostatic equipment the Service can furnish copies of rare reports or publications which are available in the numerous libraries of the District of Columbia. Such copies are furnished at twenty-five cents per sheet.

COST

No charge is made for replies to inquiries which do not necessitate special search or expenditure. Requests which demand considerable expenditure are acknowledged with an estimate of the necessary cost. The Service then awaits instructions.

It often happens that expensive information has previously been compiled. Multiplication of requests, therefore, tends towards increased economy in the Service. Appeal for assistance in the interest of science and technology as often as needed is earnestly invited.

Cultivation Experiments in the Hilo District.

By J. A. Verrett

Hilo Sugar Co., Exp. 14, Hilling.
Hilo Sugar Co., Exp. 15, Surface Hilling.
Hilo Sugar Co., Exp. 16, Off-Barring.

In this series of tests, various cultivation practices were compared. These included off-barring, hilling and plowing. Three crops have now been harvested during a period of six years.

The experiments were located in field 22, Hilo Sugar Co., at an elevation of five or six hundred feet. The cane was Yellow Caledonia, second, third and fourth ratoons.

Fertilization was uniform to all plots and according to plantation practice. There were nine to ten repetitions of each treatment.

The results from three crops show that off-barring lowered the yield of sugar. Hilling produced the same results. Surface cultivation produced more sugar than where plows were used.

These results indicate that weed control should be accomplished with the least possible disturbance to the root system of the growing cane. If the soil conditions are such that it is necessary to use plows, this should be done as early as possible before the root system of the young ratoons has become established. Even then, one must know that there is some check, as, until the new shoots have root systems of their own, they feed to some extent through the old root system by way of the old stumps.

In cases where the soil packs very hard it may be necessary to off-bar in order to have loose soil for surface cultivation later, in weed control. Otherwise, one would have to plow in the weeds. We believe it is better to off-bar early than to have to plow close to the cane later.

The cultivation of young cane can be expressed in a basic way as follows:

Control weeds in the most efficient way with the least possible disturbance to the root system of the growing cane. No one system can be the best all the time. The methods to use will vary with the time of year, the amount and cost of labor, etc.

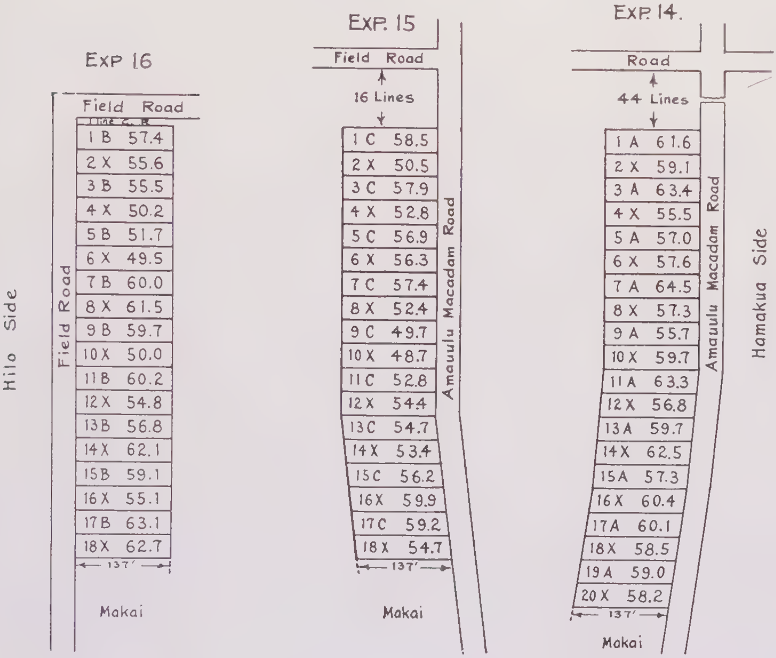
HILO CULTIVATION EXPERIMENTS

EXP. 14 HILLING - AN AVERAGE OF 1919, 1921 & 1923 CROPS

EXP. 15 SURFACE CULTIVATION - AN AVERAGE OF 1919 & 1923 CROPS

EXP 16 OFFBARRING - AN AVERAGE OF 1919, 1921 & 1923 CROPS

Field 22



EXPERIMENT 14—HILLING

This test comprised a total of twenty plots, each one-tenth of an acre in size and consisting of six lines. The two outside lines of each plot were discarded at harvest and the four middle lines only used as experimental cane. Every other plot was hilled, the alternate ones were not. In all other respects all plots received identical treatments.

The results obtained from three crops are summarized as follows:

Treatment.	Tons of Cane per Acre. 1919 Crop.	1921 Crop.	1923 Crop	Average Q. R.	Average Tons Sugar per Acre.
Not hilled	60.9	68.4	51.2	7.75	7.77
Hilled	57.0	66.8	51.9	7.88	7.44

In the following table are given the maximum and minimum plot yields of cane for each series of plots for each crop.

Treatment.	Tons of Cane per Acre. 1919 Crop.		1921 Crop.		1923 Crop.	
	Max.	Min.	Max.	Min.	Max.	Min.
Not hilled	66.9	55.4	77.2	64.0	58.9	45.6
Hilled	65.2	51.2	77.3	56.2	55.8	45.2

From the above table we see that in two out of three crops the maximum yield was obtained from the not-hilled plots, while in two crops out of three the lowest yields were from hilled plots.

Details of Experiment

Object:

To compare hilling with no hilling.

Location:

Hilo Sugar Company, Field 22, along Hilo side of Amauulu macadam road.

Crop:

Yellow Caledonia, fourth ratoons.

Layout:

Number of plots, 20. Size of plots, 1/10 acre each, consisting of 6 lines, each 5.3′ wide by 137′ long. Lines 1 and 6 of each plot are guard lines.

Plan:

A plots (odd) not hilled up, otherwise regular cultivation practice.
X plots (even) hilled.
Fertilization—Uniform by the plantation.
Experiment planned in 1917 by L. D. Larsen.
Experiment laid out in 1917 by W. P. Alexander.

EXPERIMENT 15—OFF-BARRING, HILLING, ETC., VS. SURFACE IMPLEMENTS AND HOES ONLY.

This test comprised eighteen plots, nine for each treatment. Each plot was one-tenth acre, consisting of six lines. In figuring the results, the four middle lines only were used, the two outside ones being discarded. The fertilization was uniform to all plots and followed plantation practice.

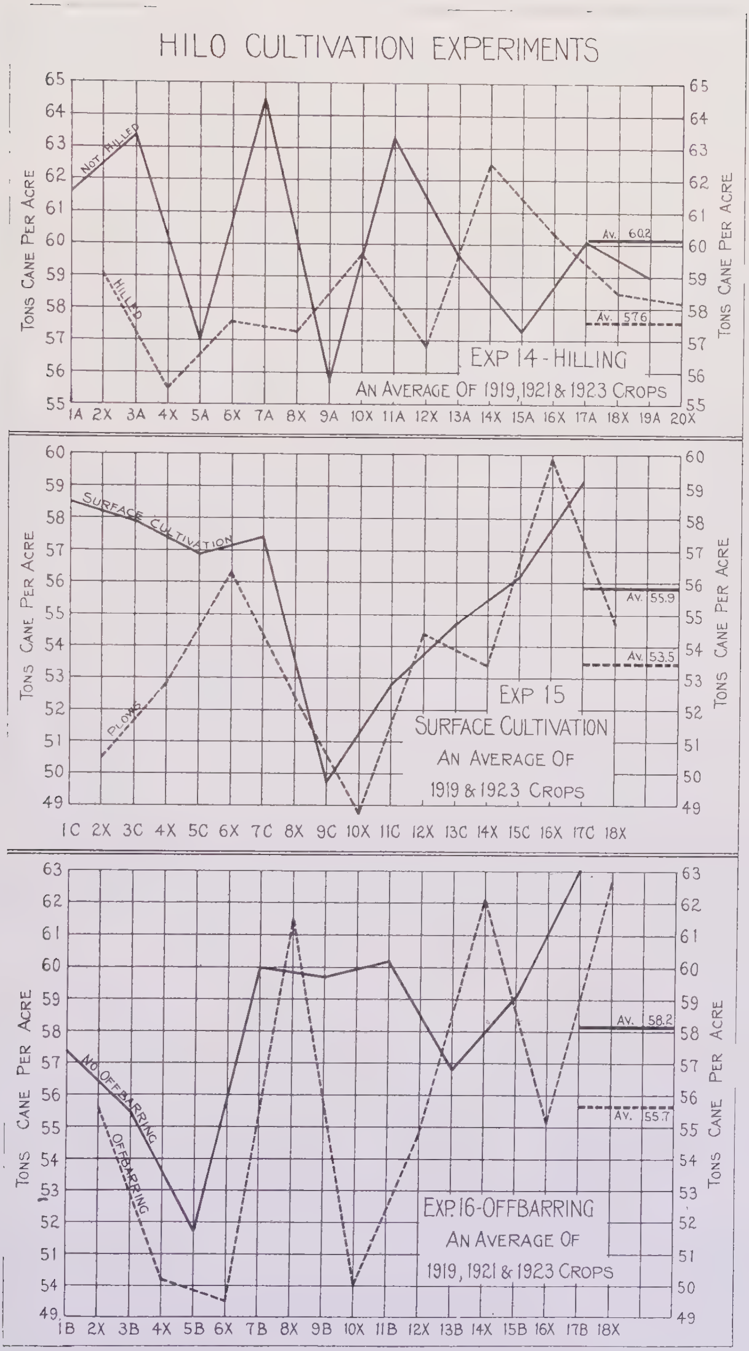
Owing to mistakes in cultivation, due to over-running of plots in plowing, this area was not harvested as an experiment in 1921.

The results obtained from two crops are given as follows:

Treatment.	Tons Cane per Acre. 1919 Crop.	1923 Crop.	Average Q. R.	Average Tons Sugar per Acre.
Not off-barred or hilled, etc......	56.2	55.4	7.99	6.98
Off-barred and hilled, etc........	55.6	51.7	8.02	6.70

The maximum and minimum plot yields for the different treatments were as follows:

Treatment.	Tons of Cane per Acre. 1919 Crop. Max.	1919 Crop. Min.	1923 Crop. Max.	1923 Crop. Min.
Not off-barred or hilled, etc............	59.9	49.2	62.5	50.1
Off-barred, hilled, etc..................	60.0	48.4	53.0	46.0


HILO CULTIVATION EXPERIMENTS
TONS CANE PER ACRE
NOT HILLED
HILLED
Av. 60.2
Av. 57.6
EXP 14 - HILLING
AN AVERAGE OF 1919, 1921 & 1923 CROPS
1A 2X 3A 4X 5A 6X 7A 8X 9A 10X 11A 12X 13A 14X 15A 16X 17A 18X 19A 20X
SURFACE CULTIVATION
PLOWS
Av. 55.9
Av. 53.5
EXP 15
SURFACE CULTIVATION
AN AVERAGE OF
1919 & 1923 CROPS
1C 2X 3C 4X 5C 6X 7C 8X 9C 10X 11C 12X 13C 14X 15C 16X 17C 18X
NO OFFBARRING
OFFBARRING
Av. 58.2
Av. 55.7
EXP. 16-OFFBARRING
AN AVERAGE OF
1919, 1921 & 1923 CROPS
1B 2X 3B 4X 5B 6X 7B 8X 9B 10X 11B 12X 13B 14X 15B 16X 17B 18X

Details of Experiment

CULTIVATION EXPERIMENT—REGULAR PLANTATION PRACTICE VS. CULTIVATION FOR WEED CONTROL ONLY.

Object:
To determine the value of ordinary cultivation, including off-barring, small plowing and hilling, against cultivation for weed control only.

Location:
Hilo Sugar Co. Field 22, on the Hilo side of the Amauulu macadam road.

Crop:
Yellow Caledonia, fourth ratoons.

Layout:
Number of plots, 18; area of plots, 1/10 acre. Each plot consists of 6 lines 5.3′ wide and 137′ long. Lines 1 and 6 of each plot to be used as guard lines.

Plan:
C plots (odd) after palipali-ing, no off-barring, plowing nor hilling; weeds controlled by hoeing and light cultivation.

X plots (even) have ordinary plantation cultivation, including off-barring, hilling, etc.

Fertilization—Uniform by the plantation.

Experiment planned in 1917 by L. D. Larsen.

Experiment laid out in 1917 by W. P. Alexander.

EXPERIMENT 16—OFF-BARRING.

This test consisted of eighteen plots, each one-tenth acre, composed of six lines each. The two outside lines of each plot were guard rows and not harvested as part of the experiment.

Nine plots were off-barred and nine alternating plots were not. All other work and the fertilization were identical to all plots.

As in the two experiments just reported, we find that the more plowing, the less sugar.

The results obtained from three crops follow:

Treatment.	Tons of Cane per Acre. 1919 Crop	1921 Crop	1923 Crop	Average Q. R.	Average Tons Sugar per Acre.
Not off-barred	59.4	62.0	53.0	8.04	7.23
Off-barred	57.1	60.7	49.3	8.28	6.73

The maximum and minimum yields obtained from the different plots for the three crops were as follows:

Treatment.	Tons of Cane per Acre. 1919 Crop. Max.	1919 Crop. Min.	1921 Crop. Max.	1921 Crop. Min.	1923 Crop. Max.	1923 Crop. Min.
Not off-barred	63.5	55.1	68.1	52.1	59.9	43.4
Off-barred	63.2	52.1	63.5	51.9	59.5	36.8

In this test, in all three crops, the highest yields were from plots which were not off-barred and the lowest were from plots which were.

A rather interesting thing in regard to these experiments is the fact that in all three of them the plots which had the least plowing had the better juices. We do not know why this should be unless it is due to the fact that in plowing the cane roots were cut, thereby causing the plants to put out new root systems, and that these, being young, kept the cane greener than was the case where the original root system was not cut.

Details of Experiment

Object:

To determine the value of off-barring and subsoiling ratoons.

Location:

Hilo Sugar Co. Field 22, on field path off Amauulu road.

Crop:

Yellow Caledonia, fourth ratoons.

Layout:

Number of plots, 18; area of plots, 1/10 acre, consisting of 6 lines each 5.3′ wide and 137′ long.

Plan:

B plots (odd) not off-barred and subsoiled after palipali-ing; otherwise regular plantation practice of hilling, etc.

X plots (even) regular plantation practice, including off-barring, subsoiling, hilling, etc.

Fertilization—Uniform by the plantation.

Experiment planned in 1917 by L. D. Larsen.

Experiment laid out in 1917 by W. P. Alexander.

The Effect of Fertilizers Containing Borax Upon the Growth of Sugar Cane.

By G. R. Stewart

Previous to the late war, compounds of the element Boron, of which boric acid and borax are the best known, had received very little attention in practical agriculture. It had been known for many years that at least traces of Boron were contained in most soils and that numerous plants absorbed minute quantities of this element. Boron had been found in a variety of fruits such as apples, pears, cherries, raspberries, figs, and in grapes and hops. Owing to its occurrence in the two latter products, traces of Boron have been frequently reported in wines and beers.

These early studies included much work on the effect of compounds of Boron upon cultivated plants grown in water cultures. A number of investigators reported some stimulating effect from very small concentrations of borax or boric acid. Stimulation has been commonly reported from minute quantities of manganese compounds, but many investigators are inclined to class managnese as an

essential element in the growth of plants. Larger amounts of borax were found to be notably toxic to practically all cultivated plants. These early experiments on Boron are excellently summarized by Brenchley (2).

When potash supplies from Germany were cut off by the war, all other sources of this plant food were developed. One of these emergency sources was potash nitrate obtained from the mother liquors of commercial sodium nitrate in Chile, and another was from the brines of Searles Lake. The potash from both these regions at times contained appreciable quantities of borax.

Owing to the widespread occurrence of borates in soil and plants it was not believed that the presence of this mineral in fertilizers would have any harmful effects. Cook (4) of the U.S. Department of Agriculture had previously used borax as a larvacide to prevent flies in manure. He applied this borax-treated manure to a variety of crops, adding amounts of borax in this way equivalent to 30.8 pounds, 46.2 pounds and 77 pounds of boric acid per acre. The effect varied with the crop to which the manure was applied, but in general it was concluded that the smallest applications of borax were safe for most crops.

Conner (3) of Indiana first reported serious borax injury to field crops from the application of fertilizers containing borax. He found definite injury to corn from as little as two pounds of borax per acre. The fertilizer containing this borax was applied in the seed drill so that the borax had an excellent opportunity to come into close contact with the young seedlings.

About this time reports reached the U.S. Department of Agricuture that extensive injury had occurred on many hundreds of acres of potatoes in Maine, and upon cotton, corn and tobacco crops in the South. This injury was traced to fertilizers that contained borates. Later experiments by Morse (6) in Maine, Jenkins (5)in Connecticut, Blair (1) and Brown in New Jersey, Neller (7) in Vermont, and Plummer (8) and Wolf in North Carolina all showed that borax was harmful to a great variety of crops, even in amounts as small as five pounds of borax per acre. As a result of this extensive experimental work, it was decided by the U.S. Bureau of Soils that two pounds of borax per acre was as much as could be applied to most field crops with any degree of safety.

Here in the Hawaiian Islands some interest arose in this problem, owing to the fact that potash nitrate, obtained from the mother liquors of the sodium nitrate industry, was being imported. Certain lots of this potash nitrate contained traces of borax, while shipments were occasionally offered to the dealers at a considerably reduced rate when appreciable percentages of borax were present. Since such notable harm occurred upon most field crops on the mainland when treated with fertilizers containing borax, it was very desirable to know the effect of borates upon sugar cane. It was quite possible that even minute traces might be harmful. Should the cane plant be shown to stand borax in appreciable amounts, there was the possibility that a saving might be effected by purchasing potash nitrate which contained borax.

A preliminary experiment as to the effect of borax upon cane was conducted by R. M. Allen at the Waipio substation of this Experiment Station. The variety of cane used was H109. Single stools were grown in small soy tubs holding 33 pounds of soil. The borax was applied in amounts equal to 10, 30, 60, 120, 240 and 580 pounds of anhydrous borax per acre. After one month's growth no

definite injury was noticeable upon any of the tubs, so the applications upon the 10- and 30-pound treatments were increased to 2,640 pounds and 5,280 pounds of anhydrous borax per acre. After another month the cane in the tubs receiving these heavy applications showed a distinct evidence of leaf-spot and burning from the borax. Some slight signs of injury were also noted upon the 580-pound treatment tubs.

This experiment in small wooden tubs suffered from several difficulties. It was hard to keep the tubs at a uniform moisture content as the soil dried out rapidly around the edges and shrank away from the side of the container. The irrigating water then ran over the outside of the block of soil without wetting the center of the pot. It was consequently hard to keep even the untreated plants in perfectly thrifty growing condition. The volume of soil contained in the tubs was also so small that shortly after the first signs of injury appeared it was evident that all the plants were rootbound and suffering for lack of space. After this point it was difficult to estimate the injury due to borax and that due to crowding the roots. It was also impossible to tell how much of the borax was leached out of the soil by the heavy watering which became necessary to try and moisten the soil completely.

A later experiment has therefore been conducted by the writer. This was intended as a preliminary study to be followed later by more detailed work. It was desirable to find, first, something as to the limits of tolerance of cane for borates and also to obtain some exact information as to the retention of borates in the soil.

In this study the cane was grown in large concrete pots two feet wide, two feet deep and two feet high, holding approximately 540 pounds of soil. Previous work with containers of this type had shown that fairly normal cane could be grown in them to an age of four to six months. H109 cane was used. Three-eye cuttings, with two eyes pinched out, were started in small nursery boxes and grown until about three weeks of age. Plants of uniform size were then selected and planted in the concrete boxes. About a week after these single eye stools were set out they were well established. They were then fertilized with a uniform application of nitrate of soda at the rate of 1,000 pounds per acre. Borax was added in seven amounts to equal 50 pounds, 250 pounds, 500 pounds, 1,000 pounds, 2,000 pounds, 4,000 pounds and 8,000 pounds of anhydrous borax per acre.

At the end of the first month's growth the containers receiving 4,000 and 8,000 pounds of borax per acre began to show visible signs of injury. This became more acute as time went on and these stools of cane were noticeably stunted but not entirely killed. There were some slight signs of injury to the leaves of the cane receiving borax at the rate of 1,000 and 2,000 pounds per acre, but no visible evidences of harm appeared on the cane receiving the smaller treatments.

The containers were all irrigated with sufficient frequency to keep the soil close to the optimum moisture content. All surplus drainage water was caught in large bottles and periodically analyzed for borax. For the first four months of the cane's growth no borax was leached out of any of the containers. The crop

A deleterious effect of borax on sugar cane growth is not plainly evident to the eye, except in applications of 4,000 pounds or more to the acre. The cane weights shown elsewhere would indicate that smaller quantities are injurious, although there is a possibility that very small applications act as a stimulant to cane growth.

was harvested at nine months of age. By that time the amounts shown in the following table had been leached out:

Borax Applied per Acre.	Borax Leached Out of Soil, Grams.	Amounts Removed Calculated to Acre Basis, Lbs.
1—Blank	None	None
2— 50 Pounds..................	Trace	Trace
3— 250 "	Trace	Trace
4— 500 "	9.35	8.8
5—1,000 "	1.77	44.9
6—2,000 "	5.78	146.7
7—4,000 "	16.56	420.4
8—8,000 "	48.23	1224.0

It will be seen that by far the largest part of the borax has been retained in the soil. With the heaviest treatment, slightly over 15 per cent of the borax applied has been leached out.

The harvesting results are given in the following table. As it is a preliminary experiment without duplicates, no close deductions should be drawn from small differences in yield. It is believed, we may safely state, that the cane plant is not particularly sensitive to borates as all the lower treatments have produced practically as good crops as the untreated blank. The smallest treatment at the rate of 50 pounds per acre may even show some evidence of stimulation. Here, again, definite conclusions will be reserved until further work has been carried out with the necessary duplication of treatments.

HARVESTING RESULTS

Treatment Lbs. Borax per Acre.	Weight of Cane. Pounds.	Weight of Tops. Pounds.	Total Weight Pounds.
Blank	7.0	4.0	11.0
50	10.0	4.5	14.50
250	6.5	3.75	10.25
500	6.5	3.50	10.00
1000	6.0	2.50	8.50
2000	7.5	3.50	11.00
4000	2.5	1.75	4.25
8000	1.0	.50	1.50

The results so far obtained confirm those of Allen, in showing that small amounts of borax are not appreciably harmful to the cane plant. The large proportion of this salt retained in the soil would warrant considerable caution in applying fertilizers with borax continuously to cane land. Further work is planned to learn more about the effect of continuous applications of fertilizers containing small amounts of borax.

The accompanying illustrations show the type of growth obtained with some of the typical treatments. The photographs were taken just before the cane was harvested.

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Experiments at Lihue Plantation Co.

By J. A. Verret.

Exp. 1, Phosphoric Acid, 1921 and 1923 Crops.
Exp. 2, Phosphoric Acid and Potash, 1921 and 1923 Crops.
Exp. 3, Forms of Nitrogen.

Two crops have now been harvested from this series of experiments, one plant and one ratoon. The cane is Yellow Caledonia. Previous to planting, the field was fallowed for one year. The trash from the previous crop was plowed in and stock was pastured on the field during the period of fallow.

The plant cane was cut back early in July, 1919, and harvested April 22, 1921. The ratoon crop was not cut back and was harvested March 5, 1923.

The results of the tests show no response at all to potash. Phosphoric acid showed some indications of crop increases, but these increases were too small to be profitable.

Equal amounts of nitrogen from nitrate of soda and from dried blood produced equal results. Applying all the fertilizer the first year produced better juices.

Lihue Experiment No. 1, Phosphoric Acid

Reverted phosphate was applied at the rate of 1,000 pounds per acre to all phosphate plots, but to the plant crop only. The ratoons received no phosphate. Eighteen plots received reverted phosphate. To nine of these, the phosphate was broadcasted before furrowing, to the other nine plots the phosphate was applied in the furrow before planting.

All plots in both crops received uniform nitrogen fertilization from nitrate of soda. In addition to the nitrate, 500 pounds per acre of molasses ash was applied to all plots in the plant crop.

The results obtained from the two crops are tabulated as follows:

Treatment	Tons Cane per Acre. 1921 Crop.	Tons Cane per Acre. 1923 Crop.	Average Q. R.	Average Tons of Sugar per Acre.
Not Reverted Phos.	42.0	31.4	8.66	4.24
1,000 lbs. Reverted Phos. broadcast	44.6	31.1	9.01	4.21
1,000 lbs. Reverted Phos. in furrow	42.3	35.3	8.90	4.36
Av. all Phos. plots	43.4	33.2	8.95	4.28

The results obtained here are within experimental error and indicate no profitable return from the phosphoric acid used. Results of the same nature were obtained on similar soils at Grove Farm. This was in contrast to results from mauka fields where good gains were had from phosphate applications.

Details of Experiment

Reverted Phosphate—Residual Effect

Object:

Too determine the residual effect of reverted phosphate on makai land at Lihue plantation.

Location:

Field 1.

Crop:

Yellow Caledonia cane, first ratoons. Previous crop harvested April, 1921. This crop not to be cut back.

Layout:

No. of plots, 33. Size of plots, 1/10 acre, 108′ long by 40.3′ wide; comprising 24 straight lines, 40.3′ long x 4½′ wide.

Plan:

Plots	No. of Plots	Treatment
A	9	1,000 lbs. reverted to plant crop—broadcast
B	9	1,000 lbs. reverted to plant crop—with seed
C	8	No reverted phosphate

All plots to receive 484 lbs. of nitrate of soda in August, 1921, and a like amount in March, 1922. No potash or phosphoric acid applied.

Experiment originally planned and laid out by R. S. Thurston.

Experiment harvested by O. C. Markwell, March, 1923.

Cane sampled in carload lots at mill by plantation.

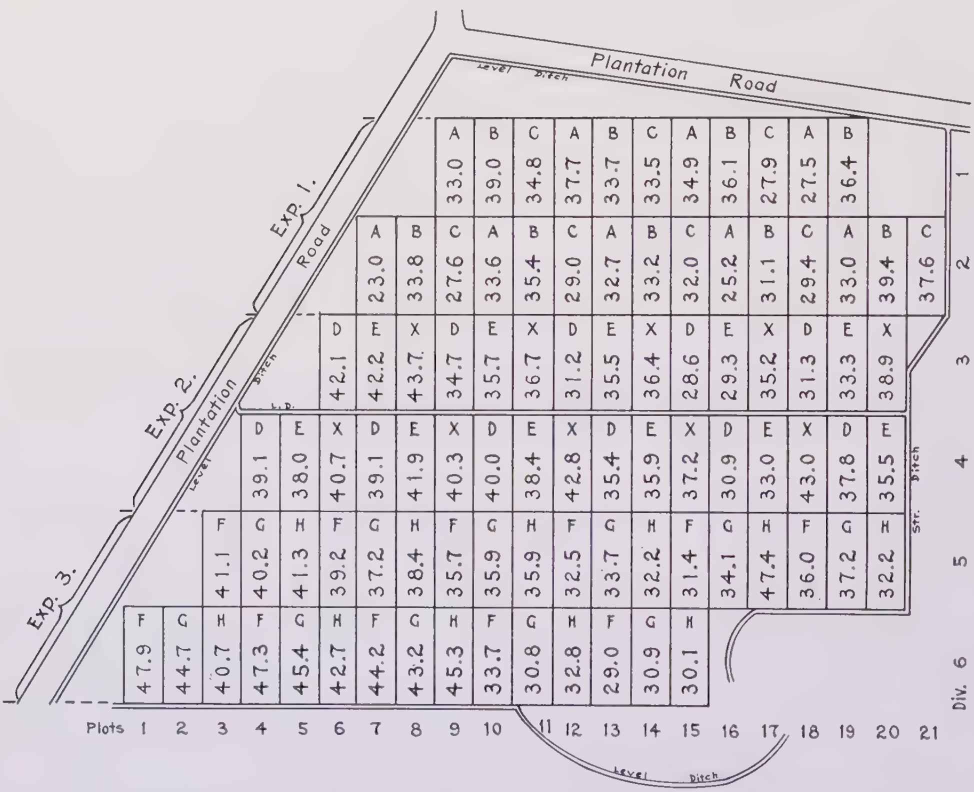
Lihue Experiment, No. 2.

In this test, all plots received a uniform application of nitrogen from nitrate of soda. In addition to this, ten plots received 500 pounds of reverted phosphate and 240 pounds per acre of molasses ash. Eleven plots got 240 pounds per acre of molasses ash in addition to the nitrogen. Eleven plots got nitrogen only.

Exp. 1. Reverted Phosphate, Residual Effect
Exp. 2. Plant Food Requirements.
Exp. 3. Forms of Nitrogen.

Lihue Plantation Co. Expts. 1, 2 & 3, 1923 Crop

Field 1.



The phosphoric acid and potash were applied in one dose to the young cane. The nitrogen was put on in two applications, one each season.

The results obtained from two crops are given below:

Treatment.	Total Pounds per Acre. N.	P_2O_5	K_2O	Tons Cane per Acre. 1921	1923	Average. Q. R.	Average Tons Sugar per Acre.
Nitrogen	150	0	0	45.2	35.4	8.49	4.75
Nitrogen and Molasses Ash	150	0	60	45.6	36.2	8.65	4.72
Nitrogen, Molasses Ash Reverted Phosphate.	150	70	60	46.5	39.4	8.61	4.92

Here, as in Experiment 1, the results are really within experimental error. There is no indication whatever of a response to potash. In the case of phosphoric acid, when the results are taken in conjunction with those of Experiment 1, there are indications of some slight response to phosphates, but this response is not enough to be profitable. But this does not mean that phosphoric acid fertilization should be discontinued as that would mean the further depletion of material from the soil and it would have to be replaced by larger doses in later years.

Details of Experiment

Fertilizer—Plant Food Requirements

Object:

To determine the value of phosphate and potash in this soil.

Location:

Field 1.

Crop:

Yellow Caledonia, first ratoons. Previous crop harvested April, 1921. Not cut back.

Layout:

No. of plots, 32; size of plots, 1/10 acre, 108′ long x 40.3′ wide; comprising 24 straight lines, 40.3′ long x 4½′ wide.

Plan:

			August, 1921		March,
	No. of		Sulf. of	Rev.	1922.
Plots.	Plots.	N. S.	Potash.	Phos.	N. S.
D	11	484	0	0	484
E	11	484	150	0	484
X	10	484	150	500	484

Experiment originally planned and laid out by R. S. Thurston.
Experiment harvested by O. C. Markwell in March, 1923.
Cane sampled in carload lots at mill by plantation.

Lihue Experiment No. 3.

In this experiment we compared equal amounts of nitrogen from three different sources, namely, nitrate of soda, dried blood, and dried blood with a spring dressing of nitrate of soda.

The amounts of material used and the time of application were as follows:

1921 CROP.		1923 CROP.		Total Pounds of Nitrogen
August, 1919.	March, 1920.	August, 1921.	Feb., 1922.	per Acre.
645 lbs. N. S.	484 lbs. N. S.	645 lbs. N. S.	484 lbs. N. S.	175
833 lbs. Blood	484 lbs. N. S.	833 lbs.. Blood	484 lbs. N. S.	175
1458 lbs. Blood		1458 lbs. Blood		175

The results obtained from the two crops are as follows:

Treatment.	Tons of Cane per Acre.		Average	Average Tons Sugar
	1921 Crop.	1923 Crop.	Q. R.	per Acre.
Nitrate of Soda	46.5	37.9	8.82	4.79
Blood and Nitrate of Soda....	45.6	38.0	8.82	4.74
Blood	43.9	37.5	8.49	4.79

These results show no preference as to which material we use as our source of nitrogen.

An interesting result of this experiment is the fact that in both crops the juices from the dried blood plots were better than the juices from the two other series of plots. We do not believe that this better juice was due to dried blood. We rather attribute it to the fact that in the dried blood plots all the fertilizer was applied the first season, and that no spring dressing was used. If the quality of the juices was affected by the blood, it should show in the second series of plots where both blood and nitrate of soda were used. But this was not the case. The average juices from the plots getting the spring dressing was the same, whether nitrate of soda or blood was used the first year. In other words, it would appear that it is the spring dressing that affected the juices, and not the blood.

This points to the great importance of careful study being made as to the value of the earliest possible fertilization as a means of improving the quality of our cane.

It is possible that it will be found advantageous to speed up our fertilizations so that all fields which are to be harvested fairly early in the year will receive all their fertilizer the first season and have the spring dressing omitted, thus giving the cane more time to mature. This would apply particularly to districts of heavy rainfall when maturity cannot be forced by the withholding of irrigation water.

Although the methods used are different, the ultimate results point to the same end. In one case we check growth by lack of water, in the other we attempt to check growth by lack of available nitrogen. But, in order not to lose much cane tonnage by the last method, it is necessary to feed the cane all the nitrogen it can possibly use in its early growth.

Details of Experiment

Fertilizer—Forms of Nitrogen

Object:

To compare the value of the nitrogen in nitrate of soda only, in dried blood only, and in dried blood with spring dressing of nitrate of soda.

Location:

Field 1.

Crop:

Yellow Caledonia, first ratoons. Previous crop harvested April, 1921. This crop not to be cut back.

Layout:

Plot.	No. of Plots.	August, 1921. Nit. Soda.	August, 1921. Blood.	March, 1922. Nit. Soda.	Total Nit.
F	11	645	0	484	175
G	11	0	1,485	0	175
H	11	0	833	484	175

Dried blood contained, approximately, 12% N.; Nitrate of Soda, 15.5%.
Experiment originally planned and laid out by R. S. Thurston.
Experiment harvested by O. C. Markwell in March, 1923.
Cane sampled in carload lots at mill by the plantation.

Liming Hawaiian Soils.

By W. T. McGeorge.

It is notable, on surveying the literature covering the liming of Hawaiian soils, that in spite of the fact that the laboratory studies strongly indicate a need of lime, comparative field experiments have rarely shown a profitable response. On the other hand, while opinions may vary, the practice of liming to a moderate extent is quite general. It may not be amiss, therefore, to compare results obtained here with some of the present day conceptions of lime requirement of soils and plants.

Field Observations

Hawaii. At Kaiwiki we note no response to lime (Yellow Caledonia cane) on applying coral sand up to four tons per acre, and burned lime at the rate of one ton per acre. Again we note no response at Hamakua Mill Co., (D 1135 cane) where ground rock and coral sand were applied up to seven tons per acre. In this case an effort was made to add enough lime to neutralize the acidity shown by analysis but samples taken later showed no reduction in acidity where two tons lime per acre were added. At Hilo Sugar Co. (Yellow Caledonia), on a soil showing five tons lime requirement by analysis, six tons burned lime and four tons sand both showed a slight response. Since these soils respond markedly to potash fertilization it is possible that response to liming in this experiment may have been due, at least in part, to a higher availability of potash on the limed plots. Greater availability of potash often results from additions of lime to the soil. At Paauhau (D 1135) 1 to 5½ tons hydrated lime gave no response; at Hawi (D 1135) ½ to 1½ tons burned lime gave no response, and at Niulii (Yellow Caledonia) a slight response was obtained with two tons lime per acre.

Oahu. At Waipio coral sand applied at the rate of ½ ton per acre, on a non-acid soil, gave a response with H 109 but none with D 1135. In similar experiments at Oahu Plantation a response was shown with Lahaina and H 109 but D 1135 again showed none. Both sand and gypsum were used in these experiments.

Kauai. At Kilauea certain tests have shown response to heavy applications of lime (Yellow Caledonia) while in others none is apparent even on acid soils. At Grove Farm no response was obtained, on virgin soil, (Yellow Caledonia) on applying as high as ten tons coral sand per acre.

Laboratory Studies

The early bulletins of the Station call attention to the readiness with which lime is leached from our soils. Makai soils are much higher in lime than mauka and cropped soils much lower than uncropped ones. In view of the relation of soil acidity to the biological activities we note special attention to have been given to this phase of liming. The replacement of other elements by lime has also been studied.

Biological activities are found to be very low in the acid soils, the addition of lime as oxide, carbonate or sulphate increasing nitrification of the soil nitrogen or that added as ammonium sulphate or blood. In the soils higher in lime less stimulation is noted. In another experiment we note burned lime and gypsum decreasing nitrification, from which variation in soil types is apparent. It is significant that in one set of experiments an increase in nitrification with increase in lime up to neutrality was found, indicating the advisability of liming to neutrality in such cases.

Coral sand has been shown to increase the nitrate content of the drainage water while burned lime and gypsum decreased it. A slight increase in the potash content was also noted while all forms of lime reduced the loss of phosphoric acid.

As regards the effect of lime on the mechanical properties we note a retarding of the movement of water, a flocculation of the clay into larger aggregates, and an increase in cohesion, apparent specific gravity, and vapor pressure.

Lime as Plant Food

Hilgard has said, "limestone country is a rich country," and Hall of the Rothamsted Experimental Station is quoted as having stated that any soil containing less than 1 per cent calcium carbonte will be benefited by liming.

Let us first consider the cane plant itself. It has long been known that certain species of plants are affected and others more or less indifferent to the soil reaction. There has resulted therefrom a botanical classification of calciphile (lime-loving), calcifuge (lime-avoiding), and indifferent; or acid tolerant, acid intolerant and indifferent. We find sugar cane thriving on a wide variety of island types. Observations, therefore, indicate that the cane is more or less indifferent to soil reaction within certain limits. It is evident, therefore, that the principal direct relation of lime to the growth of cane is as a source of plant food, or at least other than as a corrector of soil acidity. The availability of calcium being lowered by soil acidity, are our soils in need of lime applications as plant food? As previously noted, lime is readily leached from our soils and is probably the dominant constituent of the drainage water, being in solution principally as the bicarbonate. With few exceptions lime as carbonate is not present in the soil. It is evident from a survey of investigations on local soils that it is present primarily as the silicate. Thus we have the acid soils as the dominant type in the islands. While a supply of calcium as a plant food for the cane is essential, it may be safely stated that the drain that the cane plant makes upon the supply of this element is, by far, less than that removed in the drainage. In other words, light applications of lime would supply the plant food needs of the cane even in those soils of low lime content and it would appear to be good policy to regularly make light applications to the soils low in lime, regardless of any indication of visible response to such practice. In experiments in which different forms of lime have been compared, those in which a response was obtained showed such with the sulphate as well as the oxide or carbonate. The former functions primarily as a plant food while the latter as neutralizers of acidity. Does this offer a clue to the fact that response to liming is rarely observed? In the absence of calcium in other forms, calcium as silicate is known to function as a source of plant food. There is present in the irrigation water and rainfall

comparatively large amounts of carbon dioxide, which source is probably augmented by that produced in the respiration of the cane roots. There results therefrom the solution of lime through a hydrolysis of the silicate in the presence of carbonated water. It is evident, then, that calcium silicate being present in appreciable amounts in our soils, supplies, except in isolated cases, the lime needed as plant food by the cane. On this basis we would not expect a response in cases where the lime functions primarily as a source of plant food, unless an actual deficiency exists.

Soil Acidity

The chief reason for applying lime to a soil is to correct acidity, the function of lime is therefore primarily that of an indirect factor in plant growth. It is a notable fact that most plants produce best growth in the absence of acidity. In acid soils we have an environment productive of low availability of the important plant food constituents of the soil, retarded decomposition of organic matter, prevalence of certain plant diseases, etc. In estimating the lime needs of our soils the Veitch method has been widely used. It is recognized that this method only measures the amount of lime which the soil will absorb under the conditions of the analysis and therefore does not answer satisfactorily the amount of lime to apply. Some of our soils containing as high as 2 per cent lime of high availability show a need of lime by the Veitch method. It is possible that in such, a part of the lime is fixed as silicate. It seems imperative, then, that a knowledge of the nature of the acidity must be considered in estimating the lime requirement. Is it due to basic exchange? Does the mineral or organic acid theory apply? Is the phenomenon of selective absorption involved? Is there present a reducing or oxidizing environment? Is the acidity due to a hydrolysis of the salts of aluminum, iron or manganese, the solubility of which is increased by acid conditions and absence of lime? The suggestion has been made by several investigators that the effect of aluminum and manganese in acid soils seems likely to prove of more importance than the neutralization of active acidity. Lime is the principal agent for rendering these salts inactive.

In the heavy island soils we note a reducing environment, high colloidal properties and absorptive power, high basicity or low silicate content, and excessive amounts of iron, aluminum and manganese as being the principal possible factors involved in the acidity of our soils. As for any actual mineral acidity the heavy nitrate applications probably furnish sufficient base to prevent such accumulation. Absence of necessary work on soil acidity, covering this phase of the problem, prevents any conclusions being drawn regarding the extent to which the above factors apply.

Biological Activities

We have in the soil a culture medium for micro-organisms which has a direct bearing on soil fertility. It is apparent, therefore, that the reaction of such a medium is of vital importance in the proper functioning of the biological processes. It has been proven beyond question that in most of our soils a stimulation of bacterial activities related to the decomposition of plant residues and especially those concerned in the nitrogen cycle results from lime applications. Investigations have indicated the optimum conditions for nitrification to

be liming to neutrality. In the heavy applications of sodium nitrate, as practiced in the Islands, we supply to the cane the plant food which lime, as our experiments show, functions in making available. It is therefore evident that we could hardly expect a response from addition of lime where nitrate is also applied if a low nitrifying power is the limiting factor.

The action of lime and nitrate of soda are therefore interrelated. In sodium, of sodium nitrate, we have a base which functions to a limited extent as a neutralizer of soil acidity. That is, sodium nitrate applications tend to lower the acidity of the soil. At the same time we are adding nitrogen in a form which liming would supply to the plant through a stimulation of the nitrification of soil nitrogen.

Mechanical Effects of Lime

There is a tendency in many of the heavy clay island types to puddle or become compact. On a normal clay soil lime tends to flocculate the clay particles and produce what is known as a crumby structure. Experiments have shown that lime acts very favorably in improving the physical properties of Hawaiian soils, thus producing a healthier medium for plant growth.

Chemical Effects of Lime

Chemically, lime possesses several important properties closely connected with the changes going on in the soil solution. In solution as calcium bicarbonate it is the principal agent involved in the basic exchanges taking place in the soil solution. While there have been opposing opinions offered as to its relation to the availability of potash, results obtained in the study of local soils show applications of lime as oxide, carbonate and sulphate, principally the latter, to increase the soluble potash in the drainage. It appears to be also favorable to the formation of more readily available forms of phosphoric acid.

Other favorable reactions include neutralization of organic toxins and the elimination of the soluble toxic inorganic salts such as aluminum. The relation of the latter has not been studied with reference to local soils, but it is probable that they may be a factor in our fertility problems.

Conclusions

A superficial observation, then, of the effect of liming the cane lands of the Islands indicates that under the present practices a deficiency of lime for plant food is the principal limiting factor in anticipating response or no response to lime applications. In spite of the fact that laboratory studies show more favorable mechanical condition, lower acidity and a stimulation of the nitrification will result from liming, only in isolated cases has the cane shown any response to this practice. This is probably due to the indifference of sugar cane to the soil reaction, within a certain range, and the heavy nitrate applications which correct the low nitrification.

While considerable work has been done on the effect of lime on the biological processes in Hawaiian soils and the effect on the physical properties, the need for further knowledge of the chemical effects and the nature of the existing acidity is apparent in attempting to explain some of the results obtained in field trials.

The Acidity of Hawaiian Soils.

By W. T. McGeorge

Hawaiian soils, while characteristically basic, are, with rare exceptions, acid in reaction and usually show a high lime requirement by the Veitch method On the other hand, experiments and general observations have rarely shown any indication that sugar cane is materially aided by liming these soils. As a whole, the results indicate an indifference to soil reaction on the part of the sugar cane plant, or an acidity, the nature of which is not toxic toward the cane roots. In view of this the question arises: Is the nature of the acidity a factor?

Comparatively little work has been published showing the relation of the lime requirement of soils as determined by the various methods and the hydrogen ion concentration in soils high in iron, aluminum, and manganese oxides and in which these oxides are often in excess of silica. Such a comparison has recently been made in this laboratory in order to obtain information relative to the nature of acidity in such types. In this case it is not a question of the merits of the different methods.

Fourteen soils were selected varying in pH* from 4.63 to 8.01. The composition of these soils as to the most important basic constituents and silica is given in the following table. The results are expressed on the air-dry basis in order to illustrate the variation in the moisture content of the soils in the air-dry state.

TABLE 1.

Partial Analyses of Soils.**

Soil No.	H_2O	TiO_2	Fe_2O_3	Al_2O_3	Mn_3O_4	CaO	SiO_2	Organic *** and Vol.
848	12.47	6.0	11.17	19.33	.18	1.23	40.9	10.63
849	14.20	7.2	10.37	18.88	.13	1.42	39.8	9.11
367	9.60	12.2	22.54	28.51	.20	.61	9.8	15.80
765	12.03	8.0	22.54	15.46	.25	1.15	15.1	11.57
186	19.60	6.0	13.56	15.09	.26	1.23	13.2	29.63
187	22.20	4.4	13.56	18.04	.25	1.01	17.5	29.63
621	4.11	7.4	21.74	27.36	.30	.98	31.7	10.69
409	9.10	10.0	15.56	25.64	.22	.84	33.8	9.09
734	8.90	5.8	14.16	28.79	1.10	.92	33.9	11.25
722	6.04	9.8	15.76	28.24	.43	.86	31.0	13.34
408	7.70	9.4	14.56	26.04	.77	.98	33.7	11.50
872	9.17	5.6	13.96	15.44	.34	3.14	42.3	10.58
3	7.00	5.0	23.74	15.51	.40	3.25	30.8	10.24

** Analyses by fusion with sodium carbonate.

*** Does not include moisture given in column two of this table.

* In expressing acidity in terms of pH a value of 7.0 indicates neutrality, above this point, alkalinity, and below, acidity.

848 is a heavy, black, clay, adobe soil, high in water soluble iron and aluminum, irrigated land, low elevation, Waimanalo plantation.

849 is the subsoil to 848 and similar in texture and color.

367 is a yellow clay loam as is also 399. Both are from Kauai upland soils, unirrigated land.

186 is a sandy loam high in organic matter and combined water from Honokaa plantation.

187 is the subsoil to 186, similar in texture but lighter in color.

621 and 408 are red clay loams from districts where rainfall is low. The former is from Pioneer Mill, medium elevation, and the latter from Ewa plantation, low elevation.

734 is a chocolate brown silty loam from a manganiferous area, Oahu plantation, upland soil, irrigated land.

722 is a brown clay loam from Waipio substation.

409 is a red clay loam, subsoil to 408.

872 is the same type as 848 but taken from a section near the sea and high in coral.

3 is a sandy clay loam from the Experiment Station plots, Makiki, derived from and underlain with black volcanic ash.

765 is a yellow silty loam from the Hilo district, rainfall heavy, land unirrigated, clay highly hydrated and high in organic matter.

These soils have been selected from sugar lands located on the four major islands, Oahu, Maui, Kauai and Hawaii, and represent lowlands, uplands, humid, and more or less arid districts.

The lime requirement or acidity of a soil is attributed to such phenomena as the actual presence of mineral or organic acids, absorptive or adsorptive properties of colloidal material, free hydrogen ions or the presence of certain specific compounds which, through hydrolysis or replacement, increase the hydrogen ion concentration of the soil solution.

Extensive and comprehensive reviews of the various methods of determining soil acidity are available (1), which makes such a review unnecessary here. Those used in this investigation include the treatment of the soil with the salts of strong acids and strong bases, for example, the Hopkins method (2) which calls for the use of potassium nitrate or chloride; weak acids and strong bases, for example the Jones method (3) using a solution of calcium acetate, the Loew (4) method using potassium acetate, the Carr (5) method using potassium sulphocyanate; weak acids and weak bases, the Truog (6) method using zinc sulphide. Other methods included the Veitch (7) and the Hutchinson and MacLennan (8) methods which utilize solutions of calcium hydrate and bicarbonate respectively; Lyon and Bizzell (9), in which barium hydrate is used in a somewhat similar manner; the Conner (10) method and that of Rice and Osugi (11), in which the hydrolysis of esters and sucrose respectively are used; Hollemann (12), which measures the per cent lime soluble in water saturated with carbon dioxide; Immendorf (13), in which a back titration of N/5 sulphuric acid, and in which the soil has been boiled, is used.

A number of qualitative tests were also applied to these soils and include the litmus paper test; those of Veitch and Truog, which have already been

described; the Comber (14) method, which uses an alcoholic solution of KSCN, the Loew (4) method, which uses a solution of KI in starch paste, and as modified by Daikuhara (4), using starch iodide paper instead of the starch paste as a test for free iodine.

QUALITATIVE METHODS

The results obtained by the qualitative methods are given in the following table:

TABLE 2.

Qualitative Tests For Acidity

Soil No	Litmus.	Veitch.	Loew.	Loew-Daik.	Truog.	Comber.	pH.
848	acid	colorless	blue	colorless	positive	dark red	4.63
849	"	"	"	"	"	" "	4.80
367	"	"	colorless	"	"	faint red	4.88
399	"	"	"	"	negative	" "	4.97
765	"	"	"	"	"	" "	5.56
186	?	"	"	"	"	" "	5.73
187	"	"	"	"	"	" "	5.98
621	"	"	blue	"	"	" "	5.98
409	"	"	colorless	"	"	" "	6.32
734	"	"	"	"	"	colorless	6.66
722	neutral	"	"	"	"	"	7.00
408	"	"	"	"	"	"	7.08
872	alkaline	red	"	"	"	"	7.67
3	"	"	"	"	"	"	8.01

Of the above qualitative methods the litmus, Veitch and Comber appear to be best suited to local soil types as an indication of absence of adequate lime supply. The Loew and Truog methods appear to be of little value, assuming the pH values as standard for comparison. The reaction involved in the latter two methods requires the presence of an acid, which in the Loew and Loew-Daikuhara methods sets free iodine from KI, being indicated by the starch paste or starch iodide paper and which in the Truog method liberates H_2S from ZnS as indicated by the lead acetate test paper. These methods apply only in those soils of pH 4.8 or less and indicate that these reactions are inhibited in our soil types or that in those soils of low H ion concentration the small amounts of iodine or H_2S are absorbed and not set free on boiling. The Comber method showed some promise of yielding information relative to the nature of the acidity, and in view of its relation to the more advanced conceptions of soil acidity, in which the salts of iron, aluminum and manganese play a prominent part, more time was devoted to a study of this method. The reagent used in this test, KSCN in alcoholic solution, will, in the presence of soluble iron, increase the concentration of $Fe(SCN)_3$ in the liquid phase to such an extent as to greatly increase the delicacy of the reaction. From the composition of Hawaiian soils, one would ordinarily attribute acidity to be in large part due to these elements.

According to Comber, the red color increases in depth on standing. As thus applied to Hawaiian soils, manganese dioxide, which is present in practically all types, introduces a factor, which, within a certain pH range, materially enhances the value of this method, or, viewed from a different light, may add to its value. In the following table are noted observations made with this test immediately after the soil had settled and at 24- and 48-hour periods:

TABLE 3.

Showing the Factor of Time in the Comber Method

Soil No. No.	pH.	15 Min.	24 Hr.	48 Hr.
848	4.63	dark red	dark red	dark red
849	4.80	"	"	"
367	4.88	light red	light red	light red
399	4.97	red	red	red
765	5.56	"	"	"
186	5.73	light red	light red	light red
187	5.98	"	"	"
621	5.98	"	blue	blue
409	6.32	"	"	"
734	6.66	colorless	"	"
722	7.00	"	"	"
408	7.08	"	"	"
872	7.67	"	colorless	"
3	8.01	"	"	colorless

This blue color was found to be due to manganese dioxide and it is apparent from Table 3 that we may expect soils of pH less than 5.5 to show a permanent test for soluble iron, while within the range of 5.5 to 7.0 MnO_2 will change the red color to a greenish blue. This change in color is due directly to MnO_2 and not to soluble manganese salts. For example, on adding MnO_2 to 848 there resulted a gradual fading to greenish blue, while on adding manganese salts there was no change in color, the red color of undissociated $Fe(SCN)_3$ being permanent.

It was further suggested by Comber that if $FeCl_3$ be added to this reagent, thus developing the red color before shaking with the soil, the iron present in the liquid phase will be displaced by the lime in all alkaline soils. As thus applied to the soils under investigation, further peculiarities were met. The observations noted were as follows: In soils 848 to 187 there was no greater amount of color than where no $FeCl_3$ was used. Soils 621 to 408 all showed no greater amount of color and turned blue in 24 hours. Soils 872 and 3 remained colorless. The results clearly show the high absorptive capacity of the soil colloids and the influence of pH range on the color of $Fe(SCN)_3$. The delicacy of the reaction in these soils is greatly increased by using an ether-alcohol solvent for the reagent.

QUANTITATIVE METHODS

A comparison of the quantitative methods of determining acidity or lime requirement with pH values is given in Table 4. In Part 1 is tabulated the methods

expressing lime requirement in terms of pounds calcium oxide per acre and in Part 2 methods of determining soil acidity which are expressed in other terms.

TABLE 4, PART 1.

Comparing pH with Lime Requirement in Pounds CaO per Acre

Soil. No.	pH.	Veitch.	Hutch. MacLen.	Lyon Bizzell.	Hopkins.	Loew.	Jones.	Carr.
848	4.63	11460	11080	11480	3570	9360	6840	7020
849	4.80	11460	13440	12820	6880	11580	8570	9000
367	4.88	6390	9070	8060	170	3630	4860	1200
399	4.97	6750	6720	7990	100	3510	3600	....
765	5.56	15120	11500	12300	100	4410	6480	4290
186	5.73	22500	9820	13230	170	6480	6680	2200
187	5.98	24510	9570	11380	170	2490	5580	1000
621	5.98	2340	1510	250	85	1480	1260	....
409	6.32	1350	2680	200	60	810	900	....
734	6.66	1350	3520	120	40	1080	1260	....
722	7.00	660	126	60	40	420	360	....
408	7.08	1680	126	310	40	330	360	....
872	7.67	660	—2680	alk.	alk.	270	alk.	....
3	8.01	660	—6630	alk.	alk.	210	alk.	....

TABLE 4, PART 2.

Soil No.	Rice Osugi*	Conner **	Immendorf***	Hollemann****
848	.0750	9.6	13.25	.008
849	.1160	4.4	13.40	.007
367	.0190	13.0	8.50	.009
399	.0130	10.0	7.75	.013
765	.0536	24.0	15.90	.015
186	.0254	10.0	20.25	.017
187	.0520	6.0	20.10	.016
621	.0150	8.0	10.0	.023
409	.0025	2.8	11.75	.020
734	.0050	10.0	14.90	.023
722	.0153	2.0	15.10	.033
408	.0136	2.8	13.00	.027
872	.0395	4.4	21.10	.081
3	.0230	2.0	24.10	.131

* Gms. CuO per 2.5 gms. soil.

** cc. N/20 alkali per 10 gms. soil.

*** cc. N/5 acid neutralized by 10 gms. soil.

**** per cent CaO soluble in CO_2 saturated water (1:5).

Let us first consider the results obtained with the Veitch, Hutchinson-MacLennan and Lyon-Bizzell methods, which in a manner involve similar principles. In the two former, amelioration of soil acidity is effected by methods closely resembling field practice, a solution of $Ca(OH)_2$ in the one case and of $CaHCO_3$ in the other. It is evident, however, that in addition to a neutralization of actual acidity, and a replacement of soluble iron, aluminum and manganese

in their soluble salts, the acidity will appear greater than it really is, due to physical absorption by the soil colloids, not denying, however, that lime may be of benefit to the soil in other ways than neutralization of soil acidity.

In the results obtained by these three methods there is a general agreement in the soils of pH 4.6 to 5.5. Soil 186 and subsoil 187 show a wide variation. From this, it is evident that in this type acidity is due to several acid constituents as shown by the different degrees of reactivity with the different basic combinations. Absorption is also a factor in this soil, at least one might interpret such from the high content of water of hydration and the resulting colloidal properties usually associated with such types. Comparing 187 and 621 it will be noted that both show a pH of 5.98, while there is a difference of 10 tons lime requirement by the Veitch method, 4 tons by the Hutchinson-MacLennan method, and 5.5 tons by the Lyon-Bizzell. These results indicate a high potential acidity in the former, probably due to the presence of acid reacting organic compounds, and an acidity in the latter of greater intensity, this soil being very low in organic content. The soils of lower H ion concentration given in the table all show a greater degree of variation. In general, it may be said that these methods, in the main, neutralize all types of acidity and will usually agree, close enough for practical purposes, on all our highly acid types where the ratio of lime absorbed by the colloids to that used in neutralizing acidity is low. But in those soils of pH 6 to 7, and these are the less important, in which there is a higher ratio of absorbed lime to that neutralized by soil acids, there is greater variation and less agreement, the Veitch method showing absorption even in the alkaline soils. Specific information relative to the nature of acidity is wanting, except that the Veitch method gives higher results, as compared to actual H ion concentration, on soils the acidity of which is due to organic matter, than where due to other factors. In other words, the Veitch method has the advantage in the case of soils of high potential organic acidity if it is desired to estimate the lime needed to neutralize the soil, as in such types this factor is not indicated by the H ion concentration.

In the Hopkins, Jones and Loew methods we have the much discussed acidity by basic replacement or absorption. It is generally conceded that these methods indicate mineral acidity as shown by the solution of aluminum, iron and manganese in the extracts of acid soils treated with solutions of the salts which are the basis of the above methods, and the knowledge that the salts of these elements react acid through hydrolysis. Practically all soils show a higher acidity where acetates are used than where chlorides or nitrates and this is strikingly apparent in Hawaiian soils. Even in our most acid types it will be noted that the lime requirement, as indicated by the Hopkins method, is practically negligible. Both KCl and KNO_3 were used and the results by both salts checked very closely. It is significant that the highest results were obtained on the soils of highest H ion concentration and in which soluble iron and aluminum salts were present in large amounts and that in these soils potassium acetate gave higher results than the calcium acetate.

The Conner and Rice-Osugi methods show quite a wide variation in the hydrolytic action of these soils as measured by the hydrolysis of sucrose and ethyl acetate. These compounds are hydrolysed or decomposed in the alkaline

soils as well as the acid and there appears to be little relation between the H ion concentration and hydrolysis, indicating that this reaction is due in part to other factors than acidity.

The Immendorf method, which acts as a measure of soluble bases is of little or no value in these highly basic soils either as a measure of lime requirement or as indicating the nature of acidity. All acid extracts of these soils were high in iron and aluminum except number 3.

On the other hand the Hollemann method which measures the solubility of lime in water saturated with CO_2 shows a very close relation to pH values. There is a gradual increase in the solubility of lime in this reagent, with decrease in H ion concentration. These results clearly indicate that the solubility of lime is definitely associated with the H ion concentration of these highly basic soils, both as a neutralizer of actual soil acidity and in the replacement of iron, aluminum, and manganese in the soil solution due to their relative positions in the electromotive series. The results obtained show beyond a doubt that acidity in Hawaiian soils is largely a question of presence or absence of readily available calcium compounds.

Carr (5) has developed a quantitative method from that of Comber, using the red color of $Fe(SCN)_3$ as an indicator, after determining the pH at which this salt becomes colorless in solution. As thus applied to Hawaiian soils some interesting results were obtained. In highly acid soils which give a positive test for iron the titration is to a green or bluish green rather than a colorless solution. A pH of 5.4 is the turning point and the change is rather indefinite. However in titrating from colorless or green to red the color change is even yet more indefinite and in the highly manganiferous soils considerable acid may be added without changing the pH. For example, an acid reacting soil containing 7 per cent MnO_2, having a pH of 5.9, on titrating with alcoholic N/10 sulphuric acid still showed a pH of 5.6 after adding 120 cc. and the red color of $Fe(SCN)_3$ had not yet appeared. The observations noted above are of considerable value in interpreting the role of manganese in the acidity of our manganiferous types.

DISCUSSION

In attempting an interpretation of these data the results show that the acid soils of the humid districts will contain considerable acid reacting organic matter of high potential acidity not indicated by the H ion concentration. Such types will usually show a very high lime requirement, but not necessarily a low pH. Other factors such as absorption or adsorption, presence of silicic acid, complex acid-reacting silicates and hydrolysible salts of aluminum, iron and manganese appear also to be a factor.

In ascertaining the role of these elements their presence is usually sought in the salt solution extracts. Table 5 gives the per cent iron and aluminum oxides present in the potassium nitrate, or Hopkins method extract, and the potassium acetate or Loew method extract of these soils.

TABLE 5.

Showing per cent Fe_2O_3, Al_2O_3 in the Salt Extracts of Acid Soils

Soil. No.	pH.	KNO_3	$KC_2H_3O_2$
848	4.63	.228	.183
849	4.80	.220	.192
367	4.88	.043	.017
399	4.97	.044	.024
765	5.56	.082	.027
186	5.73	.085	.056
187	5.98	.073	.022
621	5.98	.100	.086
409	6.32	.189	.180
734	6.66	.072	.097
722	7.00	.113	.158
408	7.08	.194	.196
872	7.67	.268	.252
3	8.01	.126	.174

It has usually been noted that (10) the aluminum content of the acetate extract is lower than that of the nitrate. This is explained theoretically by the difference in the hydrolytic products of the reactions involved, namely aluminum acetate, of which the products of hydrolysis are aluminum hydrate, and free acetic acid and aluminum nitrate which is retained in solution as the acid salt. In the acid soils of pH 4.6 to 6.3 the iron and aluminum content is less than in the nitrate extract, while in the soils of pH 6.6 to 8.0 this relation does not hold. Judging from the color of the ammonium precipitate and qualitative tests, iron was present principally in the extracts of the more acid soils while scarcely more than a trace was to be found in the extracts of the soils of pH 6.0 to 8.0. It should be noted that the extracts of the alkaline soils contained just as much or possibly more iron and aluminum than those from the acid soils. The formation of acid salts is, however, inhibited by association with higher soluble lime content.

This influence of easily soluble bases is apparently a very important factor. The solubility of silica and silicates is of some importance. The ratio of iron, aluminum and calcium to silica was determined by using N/5 nitric acid as a solvent and the results are given in Table 6.

TABLE 6.

Showing Ratio of Easily Soluble Bases and Silica as Measured by Solubility in N/5 Nitric Acid.

Soil No.	$\%SiO_2$	$\%Fe_2O_3$	$\%Al_2O_3$	$\%CaO$	pH.
848	.120	.032	.468	.435	4.63
849	.137	.026	.552	.396	4.80
367	.012	.005	.313	.051	4.88
399	.012	.100	.182	.108	4.97
765	.097	.022	1.518	.145	5.56
186	.252	.043	3.920	.423	5.73
187	.386	.032	3.830	.141	5.98

Soil No.	$\% SiO_2$	$\% Fe_2O_3$	$\% Al_2O_3$	$\% CaO$	pH.
621	.067	.008	.175	.176	5.98
409	.105	.007	.138	.202	6.32
734	.270	.004	.537	.278	6.66
722	.116	.006	.233	.253	7.00
408	.141	.009	.174	.269	7.08
872	.287	.031	.602	1.045	7.67
3	.493	.011	1.585	1.185	8.01

It will be noted that in all types easily soluble, aluminum is far in excess of iron and highest in the highly organic soils. In general, all four constituents show wide variations in the different soil types and there appears to be no relation between their ratio and acidity. Apparently, the mineral acidity or H ion concentration is not primarily entirely a function of the solubility of these elements, but rather a function of other factors which limit the formation of acid or basic combinations.

Eliminating such abnormal types as 848 and 187 and considering only those in the series which are more typical of the average island soils, there is a tendency toward decreasing solubility of aluminum compounds, less so the iron, and an increase in soluble calcium compounds with decrease in H ion concentration. This ratio probably has an important bearing on the mineral acidity or acid-reacting compounds of these elements.

EVIDENCE OF MINERAL ACIDITY OR PRESENCE OF ACID REACTING INORGANIC COMPOUNDS.

As previously noted in the ammonia precipitates obtained on the nitrate and acetate extracts, only traces of iron were present even in soils 848 and 849, both of which gave strong tests for iron salts by the Comber method. This type of acidity is greatest in the heavy clay soils in which drainage is poor and aeration low and of which the above two samples are typical. Iron, then, is not an important factor in the acidity of average island soils and its activity is confined to the most acid types, and even in these evidently plays a secondary role to aluminum.

Manganese, on the other hand, is a factor only in those soils of low acidity. Of the manganiferous samples examined, the pH values were all 5.9 or higher. It was noted also, in an examination of the subsoils from these types, that in all cases the subsoil was of a lower H ion concentration than the top soil. Expressed in pH values the difference was .6 to .9 pH less acid. Judging from the relative positions of calcium and manganese in the electromotive series one would theoretically anticipate such to be true. The calcium apparently replaces manganese in the soil solution, the latter usually occurring in these soils deposited on the soil grains as a coating, while the characteristically open texture of the manganiferous soil favors the leaching of lime into the subsoil.

Aluminum is present in easily soluble form in all island types, highest in the humid districts and lowest in the arid. Apparently one of the principal roles which lime plays in Hawaiian soils is in its relation to the acidity of aluminum salts which appear to be present in available form even in the alkaline types.

This is best shown by the progressive increase in per cent lime soluble in water saturated with CO_2 with increase in pH, and the further fact that aluminum appears to be present in equally available form in the acid and alkaline soils, since aluminum may be present either as an acid or basic salt, depending upon environment. It is significant that soil 186 represents a comparatively unproductive area, much more so than 848, for example, although the latter is a much heavier soil and very poorly aerated. It has been found that phosphate is much more available in the lowland sections of the Islands than in the uplands. The principal inherent differences in the soils from such districts are higher acidity and lower lime content of the latter, and a greater rainfall. An investigation of these phenomena indicates that in the absence of lime in the more acid upland soils phosphoric acid has combined with aluminum, which compounds have become hydrated and hence less available as there is no consistent difference in the total phosphate content of upland and lowland soils, the principal variation being in the availability. It is believed that these facts lend some indication of the presence of acid mineral salts and that they are a factor in the acid reaction of island types.

The importance of silica as a factor in this acidity appears to be, at least, closely related to that of aluminum. Silicates are present in Hawaiian soils in a comparatively soluble form, as is shown by its presence in the island streams and its solubility in the dilute and strong acid extracts of the soil. It will be noted in Table 4 that the lime requirement as determined by potassium acetate is greatly in excess of that shown by extraction with a solution of potassium nitrate. In the case of aluminum silicate the acidity from potassium acetate is due entirely to acetic acid formed from the hydrolysis of aluminum acetate. There results a greater acidity than where acid salts are formed and relatively less aluminum in solution.

Also when anhydrides become hydrous there is a greater tendency to assume acid or basic properties. This would apply to oxides of iron and aluminum as well as silicates and it is evident therefrom that these compounds are more or less amphoteric depending upon environment. In our humid districts, or those in which rainfall is heaviest, there has been noted a rapid leaching of lime. Where present as a double silicate of calcium and aluminum there may result a complex aluminum silicate containing no lime and of more acid tendencies. Soluble forms of lime have been found to be very low in the soils from these districts. The acid or alkaline state of aluminum silicates will depend upon the amount of water of hydration and ratio of silica to alumina. Conner (10) found that ignition destroys the acid-reacting properties of clays as determined by the Hopkins method. Loss of water of constitution therefore lowers the acidity of aluminum silicates. He found that those silicates of low water of combination were not acid and that those containing considerable water and silica were highly acid. Applying these theories to island soils we find the soils from the districts of low rainfall to be low in acidity, while the reverse is true of the soils from the humid districts. Examples of the former are soils 621, 408, 409, 734, 722, while soils 765, 186, 187 will illustrate the latter. The higher organic content of the latter must, however, not be overlooked. The largest humid district under cane cultivation is the Hamakua coast section on the Island of Hawaii.

Available lime and potash are low in this section and water of constitution or hydration is high. The moisture content of the air-dry soil is often as high as 25 per cent and the maximum water holding capacity over 100 per cent. Such conditions actively favor the formation of acid aluminum silicates. There is a progressive decrease in rainfall from the Hilo section of this coast to the Kohala district at the northernmost extremity of the island. Accompanying this decrease in rainfall there is a decrease in maximum water-holding capacity, water of hydration and acidity of the soil, all of which lends proof that the acidity of our humid districts is due in a large measure to alumino-silicic acids or acid silicates. In the drier sections where the cane is grown under irrigation, rainfall being too low to support maximum growth, we find more lime present in soluble forms and that in these more or less arid districts there is decidedly less response to potash fertilization. It may be of interest to state that the water of hydration is lower in the soils from these districts, the moisture content of the air-dry soil usually being within the range of 5-10 per cent. We have under these conditions more active double silicates of potash, lime, soda, and magnesia which partially prevent the formation of the alumino-silicic acids through neutralization.

SUMMARY

In this paper are reported the results obtained on application of the Hopkins, Jones, Loew, Carr, Truog, Veitch, Hutchinson-MacLennan, Lyon-Bizzell, Conner, Rice-Osugi, Hollemann, Immendorf and hydrogen electrode methods of determining soil acidity as applied to highly basic laterite soils.

While some comments have been offered regarding the merits of these methods on such soil types the main purpose has been to interpret therefrom the nature of soil acidity in our island soils.

In the humid districts acid-reacting organic matter is an important factor, while in those sections of low rainfall this is true to a much less extent.

Mineral acidity is due in most part to aluminum salts and alumino-silicates, the later predominating in the humid districts. Iron is a factor only in the very acid soils of pH 4 to 6 while manganese is a factor only in the less acid types of pH 5.5 to 7. Water of combination or hydration is also an important factor in all types.

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Notes on Seedling Work—1923 Oahu Propagation.

By Y. Kutsunai

In October, 1922, several trips were made to learn the tasseling conditions in respect to seedling work. About 4,400 tassels were collected between November 22, 1922, and January 22, 1923, a period of two months. About a quarter of a million seedlings germinated. About 100,000 were transplanted, and of these 40,000 were sent to Manoa substation, 25,000 to Waipio substation, 15,000 retained at Makiki, and 3,000 sent to Vineyard Street nursery. A few flats, each containing three to four thousand seedlings, were given to Ewa Plantation Company and Kamehameha School. At the end of April, 1923, Waipio and Makiki had finished planting seedlings, while the Manoa substation had put out about 10,000 of them.

Details of this year's seedling work are here recorded:

Plan

This year, cane seedlings for unirrigated mauka fields were to be the major object and as many as possible were to be grown. Seedlings for warm, irrigated fields, and other special seedlings were to be grown on a small scale. Accordingly, the following plan was adopted:

(1) As many tassels as possible to be collected from the following:
 Red Tip,
 Striped Tip,
 Yellow Tip,
 Other mauka canes.

(2) Tassels wanted in small quantities:
 H 109,
 Striped Mexican,
 Lahaina,
 D 1135,
 H 5978.

(3) Special tassels wanted for special reasons:
 Uba,
 Badila,
 H 109 seedlings, 1918 O. P.,
 Native canes.

General Survey of Available Tassels

In October, 1922, extensive trips were made throughout the island of Oahu to locate fields in which the above tassels were likely to be available. Permission to secure tassels from these fields was also sought. Conditions found were:

Tassels of	Availability.
Striped Tip	Very few
Yellow Tip	None
Red Tip	None
H 1801	Many
H 3001	Very few
H 109	Many
Striped Mexican	Very few
Lahaina	Many
D 1135	Many
H 5978	Many
Uba	Very few
Badila	Many
H 109 Seedlings, 1918 O. P.	Very few
Native canes	Very few

In view of the shortage of Tip tassels, Mr. W. C. Jennings, of Kohala, was requested to supply Makiki with Tip tassels in exchange for some of the tassels abundant on Oahu.

Choosing Field For Cutting Tassels

Spots were chosen where two desirable varieties grew near each other, preferably the pollinating variety to the windward side, developing tassels a little earlier than the variety to the leeward side where the tassels were to be cut. The following fields were chosen from this standpoint:

Mother Variety.	Field.
H 1801	Makiki field 11
H 109	Honolulu Plantation Co. field 26
H 109	Ewa Plantation Co. field 25A
H 109	Makiki field 2
H 109	" " 3
Striped Mexican	Waipio substation field 37
Lahaina	Honolulu Plantation Co. field 26
D 1135	" " " " 12
H 5978	Makiki field 11
Uba	Federal Exp. Station field
Uba	Makiki field 12
Badila	Ewa Plantation Co. field 25A
H 109 Seedlings	Makiki field 18
Native canes	" " 12
Striped Tip	Manoa field 6

That there should be two or more varieties flowering close together and at the same time for proper development of seeds (caryopsis) of sugar cane was clearly brought out by H 109 seedlings grown at Makiki in 1918, and 1923. On

December 28, 1917, in an Ewa field of solid H 109, 400 tassels of H 109 were cut from which only two seedlings of any value were obtained; on the other hand, 150 tassels of H 109 cut on the same day in Waipio field O, where other varieties were blooming at the same time, gave 45 strong seedlings, showing a ratio of 5 to 300 seedlings per 1,000 tassels. On December 8, 1922, in Ewa field 25A, 135 tassels of H 109 were cut on the leeward side of other flowering varieties and planted in comparison with 15 tassels of H 109 which had no other variety in bloom to the windward side. Forty seedlings per tassel were obtained from the former while 2 seedlings germinated per tassel of the latter, giving a ratio of 20 to 1.

Tasseling Season

The tasseling season opened November 1, 1922, and closed about the middle of January, 1923, a period of two and one-half months. In general, the tassels appeared in the following order:

H 1801
H 5978
D 1135
Lahaina
H109
Striped Mexican
Yellow Caledonia
Badila and Uba

The time of tasseling was affected by the vigor of the cane. Sticks that had made good growth tasseled earlier than the stunted sticks, but those that had been very much forced failed to tassel entirely. More and earlier tassels appeared along the ditches, and the leeward edge of the fields, than elsewhere.

Cutting Tassels

Cane tassels take about a month to ripen after appearance, as shown by the following averages:

	Tip of Tassel.	Middle	Bottom
Emergence................	1st day	7th day	10th day
Pollen sacks opened.......	7th day	10th day	12th day
Stigmas opened...........	9th day	12th day	15th day
Ripened..................	24th day	27th day	30th day

Each variety had its own peculiarity in this respect, but there was not much deviation from the above table.

Tassels were deemed ripe when the fuzz would fly away at a gentle shaking, and the stems of the tassels developed straw yellow when the tassels became ripe. This change of color was not noticeable in red canes like D 1135, Badila, and Red Tip. Young tassels appeared pinkish on account of the presence of active stigmas; when dried, the tassels became whiter. When in doubt a small quantity of the fuzz was rolled forcibly in the palms of the hands and examined with

a pocket magnifier of 8 to 20 diameters, to see whether or not the seeds had dried enough to resist crushing. This method was also applicable in determining, roughly, the quantity and quality of the seeds present in the tassels.

The cutting party was composed of two men, equipped with an eight-foot trimming pole, a number of empty flour sacks that had previously been washed clean and dried, a number of shipping tags, twine, a note book, etc. One man cut the tassels at a point about a foot below the lowest fuzz branch, and the other man collected five to ten tassels, in each sack. If the tassels were cut a trifle too green, low cutting, that is, one or two joints left on the tassel, would help maturing. On the other hand, if the tassels happened to be overripe, fuzz only could be collected in the field. The sacks containing the tassels were hung in an airy room and dried for from one to three days.

Immediately after a shower the standing tassels in a field remained closed, so much so that it was extremely difficult to observe whether or not the tassels were ripe enough for cutting. Moreover, the very wet tassels often heated up and became moldy in the sacks, without properly drying. If the wet tassels have to be cut they should be hung in small bundles, or loosely, in a well ventilated room.

Early Tassels vs. Late Tassels

Effort was made to obtain an abundant supply of tassels as early as possible, partly to speed up the seedling work and partly to insure successful germination by increasing the chances of trying out a large number of sample tassels. Tassels standing in a field are subject to the disastrous rain and wind storms which usually occur towards the middle or the latter part of the tasseling season. If an approaching storm could be foretold, tassels should be hastily collected, even if a trifle too green. Germination from the earliest tassels was by far the best, from the standpoints of both vigor and number of seedlings.

Tassels Collected For 1923 Oahu Propagation

Lot No.	Parent Cane	Plantation.	Date Cut.		Number of Tassels Cut.
1	H 1801	Makiki	Nov.	22	5
2	"	"	"	23	60
3	"	"	"	23	25
4	"	"	"	24	77
5	"	"	"	24	8
6	"	"	"	28	243
7	H 8901	"	"	28	1
8	H 8910	"	"	28	12
9	H 8913	"	"	28	4
10	H 8991	"	"	28	1
11	H 89102	"	"	28	1
12	D 1135	Aiea, Field 12	"	30	173
13	H 5978	Makiki	"	29	73
14	Str. H. 109	"	"	29	12
15	H 8901	"	Dec.	2	3
16	H 8910	"	"	2	5
17	H 8911	"	"	2	3

Lot No.	Parent Cane	Aiea, Field 12 Makiki	Date Cut. Dec. 2	Number of Tassels Cut.
18	H 8961	"	" 2	2
19	H 8994	"	" 2	5
20	H 109	Ewa 25A	" 3	15
21	H 109	"	" 3	18
22	Str. Mex.	Manoa	" 5	15
23	H 8901	Makiki	" 6	3
24	H 8929	"	" 6	9
25	H 8949	"	" 6	1
26	H 8961	"	" 6	3
27	H 8994	"	" 6	19
28	H 8913	"	" 6	7
29	H 8952	"	" 6	11
30	D 1135	Aiea 12	" 6	225
31	H 8985	Makiki	" 7	7
32	H 8988	"	" 7	6
33	H 8991	"	" 7	12
34	H 89102	"	" 7	11
35	Kea	"	" 8	3
36	"Molokai"	"	" 8	3

Lot No.	Parent Cane.	Plantation.	Date Cut.	Number of Tessels Cut.
37	Laukona	Makiki	Dec. 8	4
38	Pauole	"	" 8	1
39	Papaa	"	" 8	1
40	Akoki	"	" 8	5
41	Palani	"	" 8	4
42	Red Tip	"	" 8	18
43	Unknown Native	"	" 8	2
44	H 109	Ewa 25A	" 8	135
45	H 109	"	" 8	15
46	H 109	Aiea 26	" 8	33
47	H 109	Hawi	Nov. 30	25
48	Str. Mex.	"	Dec. 4	25
49	Str. Tip	"	" 4	25
50	" "	"	" 6	25
51	Badila Sdlg. 110	Manoa	" 11	10
52	1917 O. P. 116	"	" 11	14
53	H 3001	"	" 11	14
54	White Bamboo	"	" 11	30
55	H 109 Pr. 94	Makiki	" 13	15
56	" 63	"	" 13	15
57	" 163	"	" 13	15
58	" 154	"	" 13	15
59	" 155	"	" 13	15
60	" 156	"	" 13	13
61	" 157	"	" 13	15
62	" 78	"	" 13	15
63	" 15	"	" 13	15
64	" 142	"	" 13	15
65	D 1135	Aiea 12	" 13	175
66	White Bamboo	Manoa	" 14	40
67	Rose Bamboo	"	" 14	6
68	H 109	Makiki	" 15	260
69	H 1801	Manoa	" 16	232

Lot No.	Parent Cane.	Plantation	Date Cut.	Number of Tassels Cut.
70	Lahaina	Aiea 26	" 17	371
71	H 109	"	" 17	391
72	D 1135	Aiea 12	" 17	415
73	H 109	Makiki	" 18	630
74	H 109	"	" 19	400
75	Kea	"	" 20	8
76	Laukona	"	" 20	7
77	Red Tip	"	" 20	8
78	Unknown Native	"	" 20	2
79	H 8961	"	" 20	5
80	H 8988	"	" 20	3
81	H 8995	"	" 20	6
82	H 89102	"	" 20	6

Lot No.	Parent Cane.	Plantation.	Date Cut.	Number of Tassels Cut.
83	La. Purple	Hawi	Dec. 19	25
84	Str. Tip	Hawi 1	" 14	100
85	Str. Mex.	Hawi 5	" 19	25
86	Str. Tip	Kohala P 2	" 18	30
87	D 1135	"	" 18	120
88	Str. Mex.	Hawi 5	" 19	136
89	Str. Tip	"	" 21	145
90	" "	Hawi 1	" 21	155
91	Rose Bamboo	Manoa	" 22	9
92	Str. Mex.	"	" 22	4
93	H 3001	"	" 22	24
94	Badila	Ewa 25A	" 28	11
95	Uba	Fed. Exp. Station	" 28	1
96	H 9802	Manoa	" 28	12
97	Badila	Ewa 25A	Jan. 2	2
98	Uba	Fed. Exp. Station	" 2	1
99	"	Makiki	" 3	2
100	Badila	Ewa 25A	" 3	3
101	"	"	" 3	7
102	Str. Mex.	Waipio	" 4	33
103	Badila	Ewa 25A	" 6	16
104	Uba	Makiki	" 9	2
105	"	"	" 15	3
106	"	"	" 22	3

Separating the Fuzz

A sack was kept open by stretching the mouth with a few hooks. Into this were introduced one or two dry tassels, which were spun fast by rolling the stems between the hands. The fuzz would fly off easily if the tassels were dry enough. Of course, the seeds would germinate without first drying, but subsequent handling would be difficult if seedlings were allowed to germinate on long branches of the tassels. The sacks containing the fuzz were properly labeled tied was not satisfactory, because of the confusion that might follow when two and hung on hooks. Attaching the labels to the twine with which the sack was or more sacks were opened at the same time. Labels were sewed to the sacks and separate pieces of twine were used for tying.

Preparation For Planting Fuzz

Soil Mixture. At Makiki a mixture of two parts garden soil and one part coral sand was used. The soil had been steamed for forty-five minutes and the sand had been washed three times, and then steamed for the same length of time. It was found imperative for the soil to be rich and mellow, to assure success. (On one occasion the street car track was laid about the time of this seedling work and a quantity of the soil dug up by the track layers was tested, with very poor results.) In this connection it may be of interest to report that bare seeds were easily germinated on a filter paper moistened with distilled water and kept in a moist chamber. Seedlings grown in this way died, of course, in a few days after coming up.

Flats. Flats were 12¾″ wide, 24¼″ long, 2¾″ deep, inside dimensions, made out of box shooks of spruce. A flat required 1 piece 13¾″x26″x½″, 2 pieces 12¾″x2¾″x⅞″ and 2 pieces 2¾″x26″x½″. Nine holes, one-half inch in diameter, were drilled in each bottom for drainage. These flats were sterilized in boiling water before use. At the same time, small pieces of burlap, say two inches wide and about a foot long, were boiled.

Fuzz Bed. The holes in the bottoms of the flats were covered with the burlap and then enough soil mixture was put into the flats to bring the leveled surface of the soil mixture about one inch below the edge of the flats. The fuzz bed was prepared as needed.

Planting Shed. A shed, or enclosure, was built to ward off the wind. The cane fuzz that would subsequently be handled in here was so light that it would be blown away with the slightest breeze. In this enclosure was constructed a crude table about two and one-half feet high. The ground should stand much water without becoming muddy, hence part of a lawn was used.

Tools Needed. A rubber hose with a fine sprayer nozzle having a provision for stopping the water, wooden labels, brads, pencils, a hammer, and towels, were provided.

Planting

A few flats containing the prepared soil mixture were placed on the planting table. A little water was sprayed in a fine mist onto the soil mixture, to make the surface moist enough to hold the cane fuzz. About one and one-half ounces of cane fuzz, representing three to six tassels, were spread evenly on one flat. Water was sprayed on, in a fine mist, until the fuzz became fully saturated, then the fuzz was tapped down lightly with the back or the palm of the hand, and more water was sprayed on, to assure thorough moistening. The flat, after having been labeled with the date of planting, the parentage of the tassels, and the lot number, was taken to a covered frame for germination.

The following method gave excellent results with a small quantity of threshed seeds for the purpose of studying the manner of sprouting the cane seedlings. This was handled by the pineapple specialists along the lines that pineapple seed are handled.

Object: To germinate cane seed.

Sugar cane seed magnified thirty diameters.
Variety H 109

Apparatus: Moist chambers, two sizes, one to be used as platform in larger one, filter paper, blotting paper, cotton, distilled water, tap water, Hg CI_2, 3 beakers, tweezers.

Method: (1) Cut blotting paper the size of moist chamber and notch the edges.

(2) Heat blotting paper and filter paper in oven for one hour at 100° C.

(3) Sterilize moist chambers with Hg CI_2 (using small piece of cotton) wash them off thoroughly with tap water, then with distilled water.

(4) Fill a small beaker with distilled water.

(5) Place the cane seed in the beaker of distilled water and wash thoroughly by stirring with glass rod. Pour off this distilled water and add more. Repeat three times, leaving seed in the last water.

(6) Take dishes, paper and beaker of seeds into the pathological transfer room and complete operations, 7, 8, 9, 10 and 11.

(7) Put the sterilized blotting paper obtained in operation 2 on the inside inverted dish, with edges turned down, then place the filter paper on top of the blotting paper.

(8) Pour some distilled water in moist chamber around edge of blotting paper.

(9) Pour off the distilled water from the seeds and empty them out on the filter paper in the middle of the moist chamber.

(10) Arrange the seeds on the filter paper in the dish, using tweezers, about ¼ to ½ inch apart.

(11) Place cover on moist chamber.

(12) Place covered dish on shelf in glass-house out of direct rays of the sun.

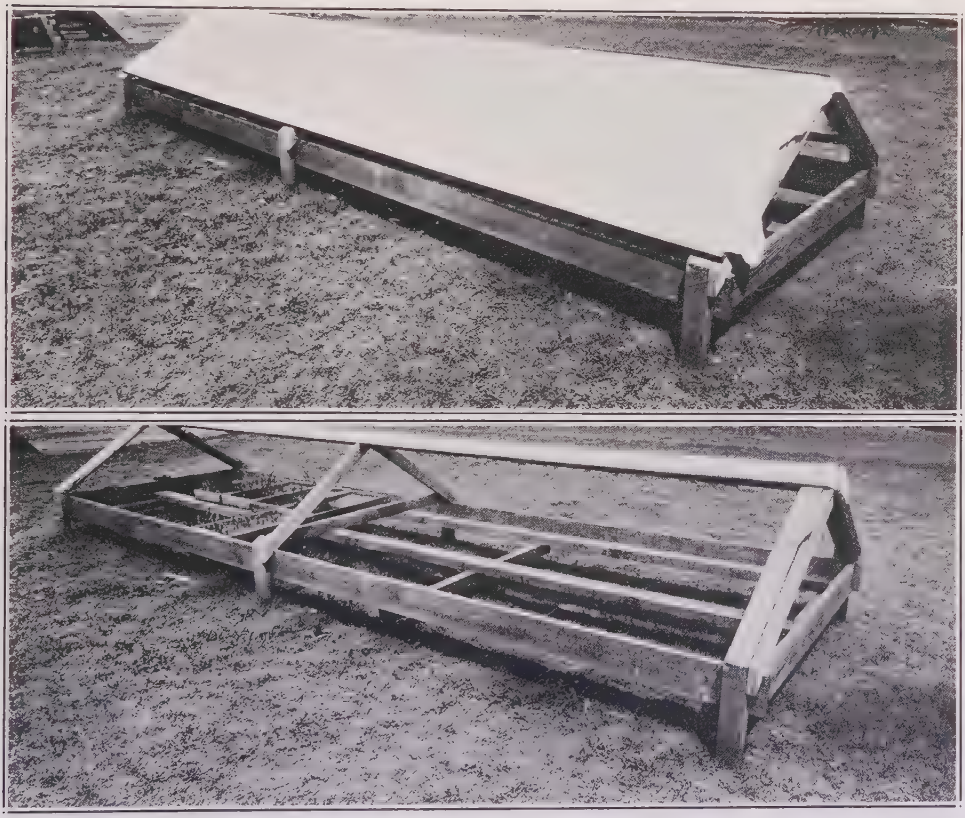
Germinating Frames

The germinating frames were very simple cold frames, made in two styles. One style had a detachable cheesecloth cover below and a glass cover on top; the other style had an unbleached cotton cover that could be rolled up. The covers in both cases were made at a pitch of about six inches or more per foot to shed rain easily. In the frames were several 2x3 strips laid in such a manner as to hold the fuzz flats about two inches above ground. Frames set on the ground were found to be just as good as those that were set about two and one-half feet above the ground.

Equipment used in germinating cane seedlings. Adequate exposure to sunlight combined with protection from heavy showers and winds has proved a very successful policy.

Water was applied to the fuzz flats in a fine spray, usually twice a day, morning and evening. The amount of water was somewhat regulated by the prevailing weather conditions.

Whenever there was a sign of rain, wind, or very bright sunlight, and always at the close of the day's work, all the germination frames were covered properly for protection. Mere covering was not enough to protect the fuzz flats during the wind storm of January, 1923, and consequently the covers had to be fastened down so firmly that there were no loose ends to flap across the surface of the fuzz, nor glass covers to fly away. In a case of this kind it would be advisable to carry the flats into a substantial greenhouse.



Frame for holding seedling flats, showing awning raised and lowered.

Germination

In from three to fifteen days, commonly four to seven days, tiny white specks appear which quickly turn green. The seedlings at this age were too small to be easily visible from above, but when the surface of the fuzz was seen across, the tiny sugar cane plants made their presence known without difficulty.

Towards the middle of January, 1923, fairly cool weather prevailed, which retarded the germination very much, and heating of the fuzz flats up to 35° C was tried with good success. The "incubation" period, that is the duration of time between the planting of the fuzz and the germination of it, seemed to be much affected by the prevailing temperature and by the age and variety of the

fuzz. One lot of tassels that had germinated in four days at Makiki took ten days to come up at a cooler locality.

Good germination was obtained in flats which had been kept under a very thin cover in a calm, sunny spot. The cover in this case was to prevent drying and not to create shade. Glass cover was found unsuitable as it checked ventilation too far and caused local burning by the intense effect of sunlight.

The extent to which the "incubation" period was affected by the age of tassels, that is, number of days between cutting and planting of tassels, is here shown:

Lot.	Variety.	Age of 3 Days.	Age of 17 Days.
61	H 109	5 days	5 days
62	H 109	4 days	6 days
63	H 109	4 days	6 days
64	H 109	4 days	5 days

The effect on the "incubation" period by the varietal difference of the tassels cut and planted on the same day is illustrated by the following example:

Lot.	Variety.	"Incubation" Period.
38	Pauole	7 days
39	Papaa	5 days

The number of seedlings germinated from a given quantity of fuzz was greatly affected by the age of the fuzz, as shown below.

400 tassels of H 109, lot 74, were cut on December 19, 1922, and planted as follows:

January	4	gave	60 to 100	plants	per	flat
February	19	"	5	"	"	"
"	21	"	6	"	"	"
"	28	"	1	"	"	"
March	7	"	0	"	"	"
"	15	"	0	"	"	"
"	21	"	0	"	"	"
April	4	"	0	"	"	"
"	11	"	0	"	"	"
"	18	"	0	"	"	"

This shows that the viability of the cane seeds has been lost almost entirely in seventy days after cutting the tassels.

Care of Seedlings in Fuzz Flats

As soon as the tiny cane seedlings appeared, they were gradually trained to face the direct sunlight, and on the fourth day they had no shade at all. Very important seedlings were handled much more carefully than the above lot, but all the seedlings that had received the full, direct sunlight from the time of germination became stronger and huskier seedlings than those that were shaded partly for protection.

The flats were watered twice a day, using a very fine spray. At about this time cutworms began to appear. Hand picking was practiced, although lead arsenate could be applied to poison the worms. Damping off fungus did not

infest the flats that had not been kept too long without transplanting. About three weeks after germinating, three and one-half grams of ammonium sulphate dissolved in 150 c.c. of tap water was applied with good results to each flat containing slow growing seedlings.

In three to six weeks after germinating the seedlings attained a proper size, say about three-quarters of an inch in height, for transplanting. If the seedlings germinated very thickly, say two thousand or more seedlings per flat, transplanting was started a little earlier in order to minimize the effect of crowding, which was found to be very serious. One flat containing about three thousand seedlings was left for test without transplanting. About one month after the time for transplanting about two thousand remained, and at the end of another month only about 500 were living. Eye-spot was more severe in heavily germinated flats than in thinly germinated ones.

First Transplanting

A good, rich, soil mixture composed of one part leaf mold or well rotted stable manure, two parts good soil, and one part of coral sand, was put in flats 12¾"x24¼"x2¾" in the same way as for the fuzz bed. Neither the components of the soil mixture nor the soil mixture itself were sterilized for fear of destroying nitrifying bacteria. In Kohala good results were obtained by using straight soil from the site of old stables. In all cases a rich soil or a rich soil mixture was the biggest factor for success.

The soil mixture was leveled off about one inch below the edges of the flats and water was sprayed onto the surface until the soil mixture became saturated but not dripping. The surface was then pressed with a device for making small holes for planting. This was a piece of board 12½ inches wide and 24 inches long, set with 120 projecting screws. The threads on the screws caught the soil mixture, when the device was lifted after pressing, making ragged holes. Pointed wooden or metallic pegs about three-eighths of an inch in diameter at the base and projecting about one-half inch would serve a much better purpose than the screws.

A fuzz flat containing seedlings about three-quarters of an inch high and a transplanting flat prepared as above stated were brought to a bench. With a pair of tweezers the mat of fuzz around the seedling to be transplanted was torn away; the seedling was taken up with the complete root system, the adhering soil, and the surrounding cane fuzz; it was then set in a hole in the transplanting flat and the hole was closed by pressing with the thumb and two fingers. When the transplanting box was filled it was labeled with the lot number and the parentage of the seedlings, the date of transplanting, and the name of the operator; it was then irrigated and taken to a transplant frame.

The transplant frame consisted of a few 2x3 pieces laid in the bottom, and a cotton sheeting roof which could be rolled up.

The seedlings were allowed to get the full sunlight gradually, and at the end of the fourth day they were practically left without protection. Wind and rain storms could be warded off by rolling down the cotton roofs and nailing

them down if necessary. Every evening all the frames were closed to avoid unexpected accidents during the night.

The flats were irrigated once or twice a day. Sometimes water was cut off entirely for one or two days, depending upon the weather conditions. About three and one-half grams of ammonium sulphate dissolved in 150 c.c. of tap water was applied to each flat about a week after transplanting. Weeds, damping off fungus, and cutworms, began to infest the flats. The weeds were controlled by hand picking, but the fungus and cutworms were held down chemically by the following methods:

Blue Green Algae and Damping Off Fungi

Blue green algae are blue green slimy algae that grow on flats and afford an ideal protection for the starting of damping off fungi. The latter attack the parts of the seedling below the surface of the soil. To check these, apply the following Bordeaux mixture to the soil surface:

3 pounds quicklime,
3 pounds copper sulphate, commercial,
50 gallons water.

Dissolve quicklime in 2 or 3 gallons of water. Dissolve copper sulphate also in 2 or 3 gallons of water. Whenever the spray is needed dilute the quicklime solution with water to 50 gallons less the amount of copper sulphate solution. If copper sulphate solution is 3 gallons, 50 gallons less 3 gallons, or 47 gallons, is the volume of the diluted quicklime solution. Into this diluted quicklime solution add the copper sulphate solution in a small stream keeping the diluted quicklime solution stirred. The stock solutions keep well, but the diluted Bordeaux mixture as made above does not retain its effectiveness long.

Cutworms

Small nocturnal moths fly to objects near the cane seedling flats and deposit eggs in batches covered with grey hair. The eggs hatch in about a week into very tiny cutworms, green or black in color and very difficult to see on cane seedlings. Sometimes the worms migrate into seedling flats from the surrounding weeds. They chew the seedlings voraciously. If a seedling is found eaten a worm can be found not very far from the spot. The worms fall off when the seedlings are touched, and therefore they can easily be caught and killed.

A mixture of 45 grams of electro lead arsenate with five gallons of water is very effective against the worms. It is sprayed in a fine mist onto the seedlings. It is well to keep the mixture agitated because the lead arsenate settles down quickly. The spray must be repeated as new leaves grow up.

Whenever the moths and the egg masses are found they should be destroyed.

Potting

Four to six weeks after transplanting, the seedlings that had reached a height of three inches or more were potted in paper pots containing a good soil mixture.

If there were only a few seedlings resulting from one lot of tassels, they were transplanted directly from the fuzz flats into pots. Some of the seedlings that had made a good growth in the fuzz flats were put into the ground, abridging the intervening transplanting, and gave good results.

Most of the seedlings raised at Makiki were sent away in the transplant flats.

The bed of seedlings in the foreground contains plants that were placed directly into the ground instead of first being planted in pots. Some of these were transplanted directly after germination and part of them were first transplanted to flats.

Paper Pots

Paper pots were introduced in 1917, when there were more cane seedlings to be handled than the number of clay pots on hand, and gradually paper pots replaced clay pots. The pots now used are made of saturated asphalt felt No. 2. The 36-inch rolls are cut into rolls six inches wide, with a band saw. Gasoline is squirted on the band saw to prevent binding. The six-inch rolls are mounted on the cutter and cut into strips 6 inches wide and 15 inches long, these being made into tubes six inches high and about four and one-half inches across. Two paper clips are used on each pot to hold the lap together. No bottoms are attached to these.

Soil Mixture

At Vineyard Street Nursery, a soil mixture of 50 per cent soil, 25 per cent stable manure, 20 per cent leaf mold, and 5 per cent volcanic ash, was used for potting, with great success. At Makiki a mixture of two parts garden soil, one part leaf mold, and one part coral sand gave moderate success. At Manoa straight soil of rather coarse texture was used with fair success. At other places a heavy adobe soil used in the pots made the growth of the seedlings very difficult. Soil suitable for this work should be fertile, draining well, and porous enough to keep good tilth.

Device for cutting paper to be used in making pots for seedlings.

Potting Out

About a week before potting, the soil in the transplant flats was cut two ways among the rows of seedlings, separating each seedling in the middle of a block of soil, and immediately, or one day prior to potting, all the seedlings that had grown three inches or more in height were trimmed of the leaves.

The pots were set in rows on a level spot. Cane trash was put in the bottoms of the pots to assure good drainage. The pots were half filled with the soil mixture. A seedling with a block of soil attached was lifted from the trans-

plant flat, with the help of a putty knife, and was set in the half-full pots. More soil mixture was added, to fill the pot to about half an inch below the upper edge. Water was given immediately, and was afterwards applied once a day. If the potted seedlings showed distress they should be shaded for a while.

A week to ten days later about one-half a gram of ammonium sulphate was applied with a wooden mustard spoon. Another dose followed this if the seedlings did not make sufficient progress.

Cane seedlings in paper pots.

Planting in Field

In six to ten weeks the potted seedlings grew to a height of one to one and one-half feet, a size suitable for planting in the field.

Furrows were made in the field, four to five and one-half feet apart, according to the standard practice of the plantation in which the first field test was to be made. Holes six inches in diameter and about six inches deep were dug, two to two and one-half feet apart, in the bottom of the furrows. The potted seedlings that had been trimmed, if necessary, and amply irrigated, were set in these holes, then the paper pots were opened very carefully to prevent sudden disturbance to the root system and the adhering soil. The empty paper pots with the paper clips which were in good condition, were gathered together to be used again.

About an ounce of ammonium sulphate or nitrate of soda was often applied in the bottom of the holes, previous to planting the seedlings.

Immediately after planting, a liberal irrigation was given, without fail. In fields where irrigation water was not available a rainy day was always utilized for the planting of the seedlings. If the seedlings showed the least sign of drying, that is rolling up of leaves, water was applied promptly.

One or two cuttings were planted here and there throughout the seedling area, for the purpose of comparing the habit of growth with the standard cane.

General Observations

The heavy germination of the seedlings during this season was largely due to the favorable weather conditions which have occurred but once since 1913. In the following table the weather conditions for the month of December only, from 1913 to 1922, are given, since the bulk of the germination was obtained in that month for the propagation of the ensuing year.

Weather Record For December of the Previous Year at Honolulu

Propagation Year.	Mean Monthly Temperature Deg. F.	Total Rainfall Inches.	Total Wind Movement Miles.	Highest Velocity of Wind. Miles per Hour and Date.	Total Number Seedlings Planted in Fields
1913	74.0	2.09	6373	32 on 23rd	3684
1914	72.4	0.52	7269	32 on 5th	1275
1915	71.1	4.37	5268	34 on 19th	4720
1916	73.2	9.18	6187	41 on 25th	613
1917	72.4	5.54	6820	34 on 10th	3295
1918	73.4	4.64	5789	31 on 27th	10154
1919	73.1	4.96	8092	53 on 3rd	9002
1920	73.4	0.90	5472	37 on 3rd	7891
1921	73.7	8.72	6075	37 on 7th	48
1922	72.6	6.12	6355	35 on 13th	1045
1923	73.7	0.66	4996	26 on 3rd	70000

A constant strong wind, as well as a strong gale at a critical moment, seems to have checked seedling work on many occasions.

Spontaneous Seedlings

A field road was plowed about the middle of December, 1922. The surrounding cane tassels were shaking off about then and the seeds must have fallen on the plowed area, because with the heavy rain of January, 1923, about two thousand young cane seedlings sprang up over the road, spontaneously. Although their parentages were totally unknown, about a thousand of them were transplanted into pots. During previous years occasional seedlings have been noted, growing along ditches and around leaky hydrants, but there had not been the opportunity for obtaining so many natural seedlings as during this season.

Green Tassels

A patch of Badila was in flower on the leeward side of H 109, which had flowered a little earlier than the Badila. The prospect for obtaining crosses between Badila and H 109 was very good indeed, but the plantation had to harvest the Badila about ten days before the tassels could ripen. In order to save the tassels the following methods were tried:

Voluntary seedlings of sugar cane which sprang up by thousands.

(a) Tassels were cut with about a yard of the stalks left on; they were carried to a nearby ditch, the cut end was again cut under water, and the tassels were left standing in the running water.

(b) Some stools with tassels were dug with a good deal of adhering soil and left standing in a ditch.

(c) Some tassels were cut as in (a), but instead of leaving them in the ditch they were transported about 20 miles and kept standing in a tank, in which the water was changed daily.

(d) Some stools were dug as in (b) and transplanted in a field some 20 miles away.

All the tassels obtained from the above four lots failed to germinate.

Special Seedlings

The latter part of November, 1922, the tassels of Uba* began to emerge at the Federal Experiment Station field, and a few days later, probably December 2 or 3, the Uba in Makiki field began arrowing. Windbreaks were built around the flowering Uba at the two stations in order to protect the delicate tassels from the action of violent winter storms.

About twenty young tassels were brought in to Makiki from Oahu Sugar Company fields once every two or three days for supplying pollen grains, to be dusted on the Uba tassels. The D 1135 tassels were cut with one to two feet of the stalks before the opening of the stigmas; the cut ends were either wrapped in moist towels or inserted in a bucket of water; the tassels were covered and tied and carefully carried to the Makiki laboratory. At Makiki the cut ends of the stalks were cut under water, and the tassels were left leaning against a table in a quiet but well ventilated room. In one to three days the pollen grains were shed, which were caught on glazed black paper spread on the table and under the tassels. The pollen grains were brushed into a cup having a cover, taken out to the field and the Uba tassels with the open stigmas were literally painted with the pollen grains by means of a soft brush. This work was in cooperation with Dr. L. O. Kunkel.

Results of Uba Tassels

Lot No.	No. of Tassels	Date Planted	Date Germinated	No. Germinated
95	2	Dec. 29	Jan. 6	2
98	1	Jan. 3	....	....
99	2	" 5	....	....
104	2	" 12	Jan. 28	3
105	3	" 16	" 26	7
106	3	" 26	Feb. 20	2

The fuzz flats were heated for a considerable time during the cold spell of January, with good results, especially with lot number 105.

The Uba seedlings were extremely delicate and did not stand handling well. Five seedlings only were successfully planted out to the field at Makiki. They were: one from lot number 104 and four from lot number 105.

Closing Remarks

Tasseling season might last three months, but collecting season could not be much longer than three weeks, during which time the slang "Get it while the getting is good" applies with particular force to cutting tassels, because no amount of effort and painstaking care could, according to experience, overcome the insufficient supply of tassels for seedling work.

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* The so-called Uba of Hawaii. This has not been positively identified as the same as the Uba of Natal.

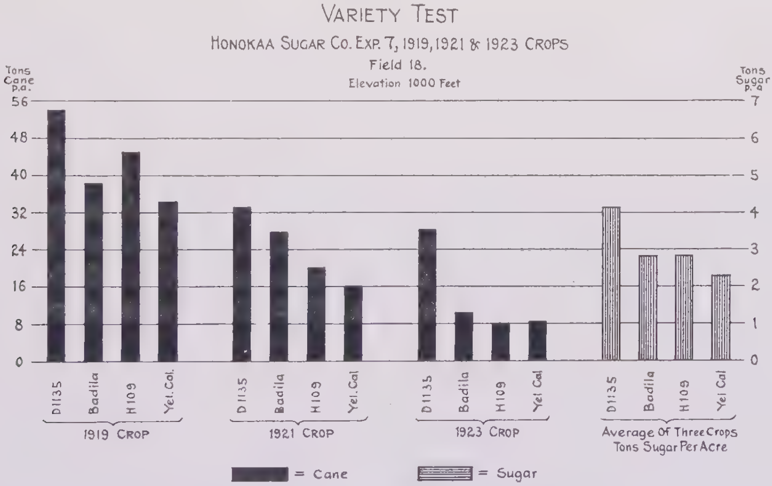
Cane Varieties in Hamakua.

HONOKAA SUGAR CO. EXP. NO. 7, 1919, 1921 AND 1923 CROPS.

In this test a comparison was made between D 1135, H 109, Yellow Caledonia, and Badila. Three crops have been harvested, one plant and two ratoon. The experiment is located in field 18 at an elevation of 1,000 feet, and is just makai of the government road, near the Honokaa village. The field is not irrigated. The 1919 and 1921 crops were 25 months old when harvested, and the 1923 crop was 19 months old.

The results obtained are given in the following table:

	Tons Cane per Acre.			Average	Total Tons Sugar from
Variety	1919 Crop.	1921 Crop.	1923 Crop.	Q. R.	Three Crops
D 1135	54.1	33.2	28.3	9.26	12.48
H 109	45.0	21.6	8.2	8.74	9.56
Badila	38.4	27.9	10.5	9.05	8.49
Yellow Caledonia	34.5	16.1	8.6	8.53	6.94



The above results show D 1135 to be far superior to any of the other varieties. This is especially the case in the ratoon crops. In the second ratoon crop the other three varieties were practically complete failures while D 1135 did pretty well, and on account of its ratooning powers was a much cheaper cane to raise.

As plant cane H 109 did fairly well, producing 45 tons of cane per acre, but it did not ratoon, the last crop producing but 8 tons of cane per acre.

Under adverse conditions D 1135 is showing itself more and more to be our best ratooner up to elevations of about 1,500 feet. We strongly advise all plantations having trouble with their ratoons to give D 1135 a thorough trial if they have not already done so.

Details of Experiment—Variety Test

Object:

Comparing Yellow Caledonia, D 1135, H 109, and Badila.

Location:

Field 18, elevation about 1,000 feet.

Crop:

Second ratoons long, previous crop harvested July, 1921.

Layout:

Number of plots: 38.

Size of plots: 1/10 acre each, consisting of 6 lines, each row 4½′ wide and 161 1/3′ long.

Plan:

Fertilization uniform to all plots same as to the rest of the field, to be done by plantation.

J. A. V.

Thinning Sugar Cane.

By J. A. Verret

It is a well known fact that a field of cane three to six months old contains many more cane stalks than will be found at harvest. A field of mature cane hardly ever contains more than three stalks of cane per running foot of row. The average is generally below three. In young cane one finds eight to ten stalks or more per running foot. Some of these stalks attain fairly large size before dying. These stalks use up plant food while living and are growing in competition with the stalks which are to live to maturity. It would, therefore, seem logical to suppose that if these stalks were prevented from growing at all, the original stalks, not having so much competition, would have a larger growth and increase the final yield of the field. These cane stalks, which grow a few months and then die, must have the same effect that an equal amount of weeds would have.

Recently a visitor to the Station, from Formosa, stated to the writer that it is the practice there to cut out about 30 per cent of the young cane shoots during the second hoeing. That would be in cane two to three months old.

With the idea of trying out the value of thinning sugar cane in an experimental way, a small test was conducted here at Makiki. For this purpose an area consisting of seventeen lines was used. The cane was first ratoons. The original planting was from one-eye seed, spaced two feet in the row. When harvested at the age of twelve months, this plant cane had 6.77 stalks per stool, or 3.38 stalks per running foot. When four months old, this same cane had about eighteen stalks per stool.

In conducting this experiment the ratoons were thinned down to eight stalks per stool, this being done when the cane was three months old. The eight largest stalks in each stool were kept and the others cut away. Any new shoots appearing were destroyed. The check plots were allowed to grow in a natural way.

The cane was harvested when twelve months old. The results showed a loss from thinning as indicated in the following tabulation:

Treatment.	Tons Cane per Acre.	Av. No. of Stalks per Foot.	Av. No. of Stalks per Stool.	Av. Weight per Stalk.	Av. Weight per Foot.
Not thinned................	55.7	3.90	7.80	3.31	12.90
Thinned....................	50.5	3.52	7.04	3.34	11.75

The above results show a difference of five tons of cane per acre in favor of not thinning. This difference in yield is due to the fact that the thinned area had less stalks of cane at harvest. Although the stalks in the thinned area were slightly heavier, .03 pound per stalk, it was not enough to make up for the lesser number present. In the thinned area we harvested 7.04 stalks per stool, the mortality after thinning being 12.5 per cent. In the unthinned area the mortality was 50 per cent. It is possible that different results would have been obtained had the thinning not been so severe. We plan to repeat the test along these lines, leaving, say, five stalks per foot instead of four.

The Availability of Iron in Manganiferous Soils

By W. T. McGeorge

Plants which do not make normal growth often develop a chlorotic condition of the leaves usually attributed to certain nutritional disturbances. Such a condition is more often noted on calcareous soils although other factors have been cited. Of the latter the chlorosis of pineapple leaves on plants grown on the manganiferous soils of Hawaii is an example.

In an investigation of these manganiferous areas and the nutritional disturbances of numerous plants grown on these soil types, Kelley (1) has reached the following conclusions: "From these evidences we may believe that the effects of manganese are largely indirect and are to be explained on the basis of its bringing about a modification in the osmotic absorption of lime and magnesia, and that the toxic effects are chiefly brought about through this modification rather than a direct effect of the manganese itself. * * * The per cent of lime is increased while the absorption of magnesium and phosphoric acid is decreased * * * ; in practically every instance a modification of the mineral balance was observed and this was found to follow the same direction * * * regardless of whether the plant showed a toxic effect."

Gile (2) has noted a development of chlorosis on pineapple plants grown on calcareous soils in Porto Rico. He found the application of iron salts to the leaves to be very effective and to induce normal growth.

Johnson (3) on the basis of Gile's work applied solutions of iron salts to the leaves of pineapple plants suffering from chlorosis on the manganiferous areas in Hawaii and noted a return of the plant to normal growth. While he appears to have published no record of laboratory investigations he concluded that the chlorosis was due to a locking up of the iron by the manganese in an unavailable form in the soil. By a recalculation of a selected part of Kelley's data he then

proceeded to substantiate his interpretation by showing a lower iron content in those plants which had become chlorotic. A study of Kelley's data in toto (1) does not indicate such to be true. The iron content of the ash of all plants analyzed shows considerable variation but no consistent relation to the manganese content of the soil. This is especially true of the pineapple plant of which Kelley made four analyses and of which only one, that cited by Johnson, showed an appreciably lower iron content in the plant grown on manganese soil as compared to that grown on a normal soil.

In a recent study on the nature of acidity in Hawaiian soils, the writer has noted certain peculiarities which may throw some light on the chlorosis of pineapple leaves grown on these manganiferous areas. Hawaiian soils, while characteristically basic, that is very high in iron, aluminum and manganese oxides, which are often in excess of silica, are usually acid in reaction. The iron content of these soils, expressed as Fe_2O_3, varies greatly and usually falls within the range of 20-40 per cent. This is true of the manganiferous areas as well as other types.

In a study of the relative acidity in manganiferous and non-manganiferous types samples of soil and subsoil were taken representing both types. The acidity expressed as pH is given in the following table:

TABLE 1.

Showing Acidity of Two Soil Types Expressed as pH.*

Soil No.	$\%Mn_3O_4$ Soil.	pH Soil.	$\%Mn_3O_4$ Subsoil.	pH Subsoil.
1. Manganiferous	7.3	5.9	3.5	6.5
2. "	4.5	5.9	3.0	6.7
3. "	4.7	6.0	3.9	6.7
4 Non-manganiferous.......	..	6.6	..	6.5
5 "	..	5.9	..	6.1
6. "	..	4.5	..	4.3

The manganese content of the non-manganiferous samples was not determined, but soils from the locality usually contain less than .5 per cent. The characteristic color of the manganese type is a chocolate brown, changing to a red subsoil at eight to twelve inches. The lower manganese content of the subsoil is typical. The above subsoil samples represent the depth below change of color to two feet. With change of color there is also a notable change in physical texture, the top soil being much more granular or, better, more silty. This may be attributed to the deposition of manganese upon the soil grains thereby increasing their size. It is typical of the manganese type that the manganese is present as MnO_2 in the form of concretions or deposited as a film on the surface of the soil grains.

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* In expressing soil reaction in terms of pH, water being practically neutral is assigned a value of pH 7.0 (neutrality). Values below 7 indicate acidity, diminishing pH increasing acidity, our most acid soils being about 4.5. Values above 7 indicate an alkaline soil.

The interreaction between metallic elements in solution is governed theoretically, at least, by their relative positions in the electromotive series, each element replacing another standing lower in the series until a certain equilibrium is reached. The relative position of the more important elements present in the soil is as follows; potassium, sodium, calcium, magnesium, aluminum, manganese, iron. It must be admitted, however, that in a soil other factors such as hydrolytic action, basic replacement, and double decomposition must be considered. Yet it is evident from the above that iron standing lowest in the series should be present in less concentration in the soil solution and that calcium and aluminum should exercise a greater displacing action than manganese, being higher in the series, and should further displace manganese itself.

In studying the relative solubility of iron and manganese in these acid soils it was found that iron salts were present in highest concentration in those soils of pH 5.5 or lower; that manganese is a factor principally in those soils of pH 5.5 or higher. This applies to all types regardless of the actual manganese present in the soil, that is whether high or low.

Now, with commercially grown crops here in the Islands, those which appear to produce normal growth on highly calcareous soils also grow with least disturbance on the manganiferous types. Reference is made to sugar cane and sisal *(Agave Sisalana)*, more particularly the latter. Until a recent date there were two sisal plantations on the island of Oahu. One was located in the coral areas practically devoid of soil, and the other in the heart of the manganiferous areas. Plants grew normally in both but slightly better on the manganese soil, due to better environment. Johnson has noted (3) that the calciphilous legumes being among the most strongly affected on manganese soils proves this element to be the cause of the chlorotic condition. He fails to point out, however, that Crotolaria, one of the most widely distributed legumes in the Islands, grows luxuriantly on the manganese soils (1). This seems more tenable from Truog's work (5), in which he found all degrees of lime requirement in legumes as well as non-legumes.

Gile (2) found that it was possible to obtain a normal growth of pineapples on a soil containing approximately 30 per cent lime by heavy fertilization with stable manure. Kelley (1) found the same to be true on the manganese soils. The form of manganese present in Hawaiian soils is extremely soluble in organic acids. It hardly seems tenable that the fertility of these soils would be increased by heavy applications of organic fertilizers if the toxicity is due directly to manganese.

In studying the relation of iron, aluminum, manganese, and lime to soil acidity in Hawaiian soils, it was found that as compared to aluminum both iron and managnese appear to be only a small factor in determining the reaction. The aluminum content of these soils is approximately equal to that of iron, but in measuring the solubility in dilute mineral acids and other weak solvents, aluminum is dissolved in considerable excess. This also is in agreement with the respective position of these elements in the electromotive series. Also, there is a direct relation between the solubility of lime and acidity. In the following table is shown the relation between the per cent lime soluble in water saturated with CO_2 (shaking 1 part soil to 5 parts water) and pH:

TABLE 2.

Showing Relation of Lime to pH in Typical Hawaiian Soils

Soil No.	848	367	399	765	186	621	722	872	3
pH	4.63	4.88	4.97	5.56	5.73	5.98	7.00	7.67	8.01
%CaO	.008	.009	.013	.015	.017	.023	.033	.081	.131

The interpretation seems tenable from the above data that lime is closely related to the concentration of the elements iron, aluminum and manganese in the soil solution of Hawaiian soils. Kelley (1) has shown these manganese areas to be of alluvial origin, the manganese having been brought into solution by leaching, ultimately being deposited in the low lying pockets. This theory is borne out by the sporadic occurrence of the manganese spots which are usually lower than the surrounding non-manganiferous types. Judging from their respective positions in the electromotive series it is evident that the lime present in the soil solution is the principal factor in this deposition of manganese. It is usually present in excess of all other elements in the soil solution and water extracts of Hawaiian soils. This further explains the lower hydrogen ion concentration in the subsoils of manganiferous types. Calcium, replacing manganese in the soil solution, increases the concentration of calcium which, due to the loose texture of this soil type, is easily washed into the subsoil. The humus content of these soils is very low. The hydrogen ion concentrations appear to be due principally to the presence of acid-reacting silicates. The lime is fixed in the subsoil by these acid aluminum silicates forming silicates of lesser acid tendencies. On determining the solubility of lime in CO_2 saturated water, the following results were obtained with the three manganese soils and subsoils:

TABLE 3.

Showing Relation of Solubility of CaO in Soil and Subsoil

	1. Soil.	1. Subsoil.	2. Soil.	2. Subsoil.	3. Soil.	3. Subsoil.
%CaO	.023	.017	.015	.010	.028	.022
pH	5.9	6.5	5.6	6.7	6.0	6.7

These results appear to indicate the presence of silicates of lesser acid tendencies in the subsoil. It will be noted that the solubility in the subsoil is lower than the soil, yet the hydrogen ion concentration is lower. The higher solubility of lime in the manganese soils as compared with the normal red soil is typical. This greater solubility of lime, the activity toward the replacement of manganese in solution as well as aluminum and iron, the open texture and better aeration in such types which assures a ready supply of air and CO_2 for the solution of calcium as bicarbonate, appear to be important factors in the chlorosis of pineapple plants grown on this soil type. It might also be mentioned at this point that pineapple roots are almost entirely confined to the surface soil; also that the development of chlorosis usually follows liming even on the more acid island soils.

Wilcox and Kelley (6) in an anatomical examination of the physiological disturbances in plants grown on manganese soils, noted a superabundance of calcium oxalate crystals in the chlorotic pineapple leaves. The chemical analysis of leaves has also shown a markedly higher lime content as compared to the normal green leaves.

Availability of Iron

Comber (4) has developed a qualitative test for soil acidity in which he shakes the soil with a solution of KSCN in alcohol. By increasing the concentration of $Fe(SCN)_3$ in the liquid phase by the use of this solvent, he obtains a very delicate test for iron, indicating the presence of acid-reacting salts of this element and aluminum. The delicacy of this test is further increased by using an ether-alcohol solvent for the reagent. As thus applied to the manganese soils all showed a positive test for iron in solution. The depth of color is just as great as in the non-manganiferous soils of equal H ion concentration. One difference was noted, however. The color of the test gradually fades in those soils, of pH 6.0 or higher, to a greenish blue. This is due to the presence of manganese as dioxide and not to the presence of manganese salts in solution. This was noted in the normal soils containing as low as .4 per cent MnO_2 and was produced in a soil pf pH 4.3 by the addition of MnO_2 but not by the addition of any amount of manganese salts.

Comber (4) attributes this reaction to a double decomposition, while Carr (7) suggests the actual solution of iron and aluminum which existed previously as colloidal basic salts. In either case the test indicates the presence of iron in readily available form in the manganiferous type and that MnO_2 does not hold the iron in an unavailable combination.

Mobility of Iron

In a very thorough study of the availability of iron and its mobility in the plant, Gile (8, 9, 10, 11) has shown certain factors to greatly influence the mobility of iron in the leaves. He found that chlorotic leaves on calcareous soils when restored to normal color by spraying with iron salts do not transfer this iron to new leaves, but the latter must be sprayed in order to maintain the green color of the plant as a whole. That is to say, with the withering of the old leaves the iron is not transported to the new. In the commercial spraying of pineapple plants in Hawaii, which is successfully practiced on an extensive economic scale, plants grown on all soils show a response to spraying with solutions of ferrous sulphate. Of course, this is most marked on the manganese soils where the chlorotic condition is more prevalent. Also, the spraying must be continued at intervals throughout the life of the plant. These facts clearly indicate the low mobility of iron even in the normal pineapple plants.

Conclusions

It is believed that the foregoing results indicate that the chlorosis of pineapple leaves on plants grown on manganese soils is due to a greater assimilation

of lime indirectly caused by the presence of manganese in excessive amounts in the soil.

The principal physiological disturbance is the greater immobility of iron in the plant resulting from the excessive lime content of the leaves and stalk and the low rate of mobility of iron even in normal pineapple leaves.

Iron is shown to be present in equally available form in both manganiferous and non-manganiferous types of equal hydrogen ion concentration. The fact that the addition of soluble iron salts to the soil is without effect and that new leaves must be sprayed indicates lack of mobility in the plant to be the principal inhibiting factor.

It is not denied that manganese under certain conditions may exert a toxic effect on plants. Numerous references in literature tell of such. This is especially true in water and sand cultures carried on in the absence of the complexities of soil environment. Also, it is recognized that manganese may displace iron in solution in water and sand cultures. The relative positions in the electromotive series proves this, but it also indicates that lime functions as such with relatively greater activity.

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Repairs Under Pressure.*

Two fatal accidents that occurred recently were directly due to the highly dangerous practice of attempting to repair boilers, steam pipes, and other closed vessels and objects while they were under pressure. We have repeatedly warned against this practice and the hazard has often been pointed out in other ways; but the frequency with which accidents from this cause continue to occur is discouraging, and it is evident that this very real danger is often ignored, or at least receives too little consideration.

* Boiler Maker, Vol. XXIII, No. 3.

One of the accidents to which we refer occurred in connection with a water-tube boiler. This boiler is one of a battery, and had been shut down for a time. In the process of putting the boiler in service again, steam had been raised to a pressure of 130 pounds, but the boiler had not been cut in on the line. A leak was discovered around one of the tube-caps in the front water leg, and the attendant tried to "roll in" the cap. The cap was of a somewhat unusual type, and during the operation it was pushed in, and a stream of boiling water under 130 pounds pressure rushed out directly into the attendant's face. The man was hurled against a coal pile about twelve feet distant and almost instantly killed.

In the other case, two men were attempting to stop a leak at the flange of a reducing tee on a steam-pipe line. They had put a packing ring or gasket in place and were tightening the bolts which compress the gasket between the flanges. This caused the steam pipe to pull out of the tee, and the parts separated a distance of about eight inches. The escaping steam blew one of the men off from a timber on which he was standing and into a concrete wheel-pit. The other man was blown from a ladder, but was able to go to the boiler room and have the steam shut off. On returning to the scene of the accident it was found that the first man was fatally scalded. He was removed to a hospital but died within a short time. It is said that previous attempts had been made to stop this same leak, but they had not been successful. It is also stated that the joint was defective, and that to prevent similar accidents in the future, the entire pipe line was soon to be dismantled and examined.

Wherever this article comes to the attention of a man who is accustomed to repair vessels of any kind under pressure, we sincerely hope it may be the means of influencing him to discontinue the practice. We know very well that work of this sort is often done without disastrous results; but there are plenty of examples of fatal cases, and no man who persists in following the practice can tell when his turn may come. Neither has any employer a right to ask a man to risk his life in this way. Delays and shut-downs may cause extra expense, but this should not be considered where human life is endangered .

[W. E. S.]

Sex Proportion in Trapped Rats and Mice.

The following table showing the sexes of rodents trapped on the island of Hawaii from Sept. 1, 1922, to Feb. 28, 1923, is of interest. I have compiled this from the weekly reports of Mr. C. Charlock, Territorial Board of Health. The sex determinations were made under the supervision of Mr. Charlock, upon recommendation of Dr. Trotter, in response to our original request for the information. So far as available literature shows, this is one of the largest sex-ratio determinations ever made on trapped rats. It has generally been assumed that the proportion of sexes is about equal and that in trapping operations more males are caught than females, under the supposition that they are

bolder and more active. The work of Petrie and Macalister in England in 1911 on this point bears out this theory. They found that of 6071 rats collected in January and February, 3273 were males and 2724 females, 74 being unrecorded. The data herein show results entirely opposite. Of 74,941 rodents caught on Hawaii between Sept. 1, 1922, and Feb. 28, 1923, 28,657 were determined as males and 46,284 as females. The explanation of this difference must necessarily be very complex and probably impossible. It is not unreasonable to suppose, however, that the great difference between climate, available food and housing conditions in England and our cane fields, plays a prominent part in this difference in catch.

The data in the table show no wide variations in the sex-ratio from month to month. It covers the warm autumn months and the coldest period of winter. There is also very little difference in the sex-proportion of one species of rodent over another. The results would tend to upset somewhat the Rodier theory of rat-control. If the sexes in the field are nearly equal, the trapping operations are constantly removing many more females than males, yet trapping as a method of economic rodent-control in Hawaii has proven a failure after many years of large operation.

PROPORTION OF SEXES IN TRAPPED RODENTS ON ISLAND OF HAWAII, FROM SEPT. 1, 1922, TO FEB. 28, 1923.

	Rattus norvegicus		Rattus alexandrinus		Rattus rattus		Mus musculus	
Month	Males	Females	Males	Females	Males	Females	Males	Females
Sept., 1922	703	1047	475	784	719	1106	2209	3094
Oct., 1922	663	1043	365	610	986	1551	1948	3272
Nov., 1922	756	1238	250	405	1206	2107	2678	4988
Dec., 1922	676	1285	270	513	1188	2331	3265	5072
Jan., 1923	730	1094	320	503	1346	2490	3177	4708
Feb., 1923	642	890	326	470	1291	1918	2468	3765
Total	4170	6597	2006	3285	6736	11503	15745	24899

Total: All forms ....28,657 Males
" " ....46,284 Females

Rodents trapped from the following localities on the island of Hawaii:

Olaa Sugar Company,
Waiakea Mill Company,
Hilo (city),
Hilo Sugar Company,
Onomea Sugar Company,
Pepeekeo Sugar Company,
Honomu Sugar Company,
Hakalau Plantation Company,
Laupahoehoe Sugar Company,
Laupahoehoe village,
Kaiwiki Sugar Co., Ltd.,
Hamakua Mill Co.,

Kukaiau Sugar Company,
Paauilo village,
Pohakea, Hamakua,
Paauhau Sugar Company,
Honokaa Sugar Company,
Honokaa village,
Pacific Sugar Mill,
Kukuihaele village.

C. E. P.

Sugar Prices.

95° Centrifugals for the Period March 16, 1923 to June 15, 1923.

Date		Per Pound	Per Ton	Remarks
March	19, 1923..	7.34	$146.80	Cubas.
"	20	7.25	145.00	Cubas 7.28, 7.22.
"	21	7.22	144.40	Cubas.
"	23	7.28	145.60	Porto Ricos.
April	5	7.345	146.90	Porto Ricos 7.28, 7.41.
"	6	7.47	149.40	Cubas.
"	9	7.53	150.60	Cubas.
"	10	7.66	153.20	Cubas.
"	11	7.72	154.40	Cubas.
"	12	7.66	153.20	Cubas.
"	17	7.78	155.60	Porto Ricos.
"	18	8.00	160.00	Cubas 7.97, 8.03.
"	20	7.91	158.20	Cubas.
"	23	8.28	165.60	Cubas.
"	26	8.41	168.20	Cubas.
"	27	8.28	165.60	Philippines.
"	30	8.03	160.60	Cubas.
May	3	7.845	156.90	Porto Ricos 7.91; Cubas 7.78.
"	4	7.41	148.20	Spot Cubas.
"	8	7.845	156.90	Porto Ricos 7.78, 7.91.
"	9	8.03	160.60	Porto Ricos.
"	10	8.22	164.40	Cubas 8.22; Porto Ricos 8.28, 8.16.
"	11	8.28	165.60	Porto Ricos.
"	14	7.91	158.20	Spot Cubas.
"	16	7.78	155.60	Porto Ricos.
"	25	8.28	165.60	Cubas.
"	28	8.16	163.20	Philippines.
June	5	8.03	160.60	Porto Ricos.
"	6	8.10	162.00	Porto Ricos.
"	8	7.93	158.60	Cubas 8.03; Spot Cubas 7.91, 7.85.
"	11	7.69	153.80	Philippines 7.66; Spot Cubas 7.72.
"	12	7.66	153.20	Cubas.
"	13	7.405	148.10	Spot Cubas 7.28, 7.53.
	14	7.22	144.40	Spot Cubas 7.16; Cubas 7.28.